DOCUMENT RESUME

ED 230 822 CE 036 371

AUTHOR	Henderson, William Edward, Jr.
TITLE	Articulated, Peformance-Based Instruction Objectives Guide for Welding. Final Document. Revised.
INSTITUTION	Greenville County School District, Greenville, S.C.; Greenville Technical Coll., S.C.
SPONS AGENCY	South Carolina Appalachian Council of Governments, Greenville.
PUB DATE	28 Feb 83
CONTRACT	ARC-211-B
NOTE	308p.; For related documents, see ED 220 579-585, CE 036 366-368, and CE 036 370-372.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052) -- Tests/Evaluation Instruments (160)
EDRS PRICE	MF01/PC13 Plus Postage.
DESCRIPTORS	Articulation (Education); Behavioral Objectives; *Blueprints; Competency Based Education; Criterion Referenced Tests; Curriculum Guides; High Schools; Industrial Arts; Mathematics; Measurement; Metal Working; Safety; Secondary Education; *Trade and Industrial Education; *Welding

ABSTRACT

Developed during a project designed to provide continuous, performance-based vocational training at the secondary and postsecondary levels, this instructional guide is intended to help teachers implement a laterally and vertically articulated secondary level welding program. Introductory materials include descriptions of Welding I and II, descriptions of secondary and postsecondary welding programs, postsecondary course descriptions, some guide organization notes, a discussion of sample tests provided in the guide, and suggested instructional time. In addition to an orientation, nine units are provided on these topics: welding safety, welding math, measuring, oxyacetylene cutting/welding, arc welding, operating gas metal arc welding equipment, gas tungsten arc welding, weld testing, and blueprint reading. Suggested instructional time and task listings begin each unit. For each task in a unit, some or all of the following are provided: performance objectives, performance actions, performance standards, recommended sources, related technical information, and other information the teacher might need. Suggested outcome-referenced tests are included. Appendixes include a sample proficiency report and exemption test, articulation materials, definitions, and test directions. (YLB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED230822

FINAL DOCUMENT FOR ARTICULATION OF WELDING

Project No. 82-1361
Contract No. ARC 211-B

Wm. Edward Henderson, Jr.
Coordinator, Occupational Education Articulation Program
The School District of Greenville County
P. O. Box 2848
301 Camperdown Way
Greenville, South Carolina 29602

ARTICULATED, PERFORMANCE-BASED INSTRUCTION OBJECTIVES GUIDE FOR WELDING

February 28, 1983

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

W Henderson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

CE036371

Occupational Education Articulation Program
Funded by
SOUTH CAROLINA APPALACHIAN COUNCIL OF GOVERNMENTS

ARTICULATED, PERFORMANCE-BASED CURRICULUM GUIDE

THE SCHOOL DISTRICT OF GREENVILLE COUNTY

DR. J. FLOYD HALL
SUPERINTENDENT

DR. NORMAN MULLINS
ASSOCIATE SUPERINTENDENT FOR EDUCATIONAL DEVELOPMENT

MRS. DORIS CLANTON
DIRECTOR, INSTRUCTIONAL SERVICES

MR. O. RICHARD COTHRAN, JR.
CONSULTANT, VOCATIONAL EDUCATION

ARTICULATION GUIDE

THE SCHOOL DISTRICT OF GREENVILLE COUNTY AND GREENVILLE TECHNICAL COLLEGE

THE SCHOOL DISTRICT OF GREENVILLE COUNTY
GREENVILLE, SOUTH CAROLINA

REVISED 1983

TO: Task Force Committee Members

FROM: Ed Henderson Jr., Coordinator
Occupational Education Articulation Program

Ed Henderson Jr.

DATE: June 1, 1983

RE: ATTACHED IS THE FIELD-TRIAL EDITION OF THE ARTICULATED, PERFORMANCE-BASED INSTRUCTION GUIDE

Attached is the field-trial edition of the Articulated, Performance-based Instruction Guide that you helped develop this school year. This document provides the basis for the initial implementation of lateral and vertical articulation between similar vocational education programs of The School District of Greenville County and Greenville Technical College.

At the secondary level, this laterally articulated curriculum guide should help ensure that similar vocational education programs of The School District of Greenville County are working from the same performance objectives and are uniform in performance standards and competency testing.

This performance-based instructional guide provides an articulated agreement concerning what should be taught at the secondary level. Therefore, it should free you to concentrate on how to teach and motivate your students. Each vocational program, of course, must be locally designed to best serve the needs of the program's students as well as potential employers.

Only you, the vocational instructor, can localize, supplement, and personalize the information contained in this Articulated, Performance-based Instruction Guide and only you can take this guide and make it work!

Your cooperation and hardwork have resulted in the development of a quality Articulated, Performance-based Instruction Guide. Following this guide in your vocational program will be the key to success of the articulation program. This Guide, at the secondary level, replaces previous curriculum guides, is state-of-the-art, locally validated, and provides the basis for building a vocational education program which will excel.

Remember however, this initial edition of the articulation guide may not satisfy every situation. Revisions will be needed and are essential to molding the final version into a practical and effective curriculum document. Please make correction and revision notes in your guide copy so that, at a later date, revisions may be made with a minimum of time and effort.

Thank you very much for your cooperation, your hardwork, and for your support of the articulation program. This project period has been an enjoyable learning experience for me and working with task force committees and vocational instructor participants has been a pleasure.

The School District of Greenville County
Box 2848-301 Camperdown Way · Greenville, South Carolina · 29602 · 803/242-6450

DISCRIMINATION PROHIBITED - Title VI of the Civil Rights Acts of 1964 states: "No person in the United States, shall, on the grounds of race, color, or national origin, be excluded from participation in, be denied the benefit of or be subjected to discrimination under any program or activity receiving federal financial assistance." Therefore, the Occupational Education Articulation Project, like all other programs or activities receiving financial assistance from the Appalachian Council of Governments must be operated in compliance with this law.

The opinions expressed herein do not necessarily reflect the position or policy of the Appalachian Council of Governments and no official endorsement by that agency should be inferred.

BIAS STATEMENT

This articulated, performance-based instruction guide has been developed based upon the tasks (objectives) and task actions (enabling objectives) important to the success of entry level workers in the vocation. The objectives were derived from task analysis and available tasks lists such as V-TEC Catalogs. The standards of performance are those expected by local businesses and industries for job success. Test samples are included to represent valid and reliable measures of the mastery of objectives.

This articulated, performance-based instruction guide has been designed to comply with the requirements of PL 94-482 Educational Amendments of 1976, Title II, which is intended to "...ensure that ...curricula do not reflect stereotypes based upon sex, race, or national origin..."

COPYRIGHTED DISCLOSURE STATEMENT

Every effort has been made to appropriately document any copyrighted material used in this articulated, performance-based instruction guide.

The objectives and task actions in this guide were developed or contributed by task force committee (instructor) participants based on their expertise and on task lists from resources such as V-TEC Catalogs. Standards included in this guide are those identified by local businesses and industries as important to the success of entry level workers. Sample knowledge and performance tests are included for the purpose of representing valid and reliable test items that may be used to measure mastery of objectives. Test samples taken from texts or workbooks are typical of those being used locally and appropriate documentation has been included.

Wm. Edward Henderson Jr., Coordinator
Occupational Education Articulation Program
The School District of Greenville County

Henderson, Wm. Edward Jr., ed. Articulated, Performance-based Instruction Guide for Welding, Greenville, SC: The School District of Greenville County (Occupational Education Articulation Program funded by the South Carolina Appalachian Council of Governments), 1983.

ACKNOWLEDGEMENT

This Articulated, Performance-based Instruction Guide for Welding is the product of the work of the following Welding instructors representing the secondary program of The School District of Greenville County and the post-secondary similar program at Greenville Technical College.

L. O. Vaughn	Donaldson Vocational Center
William W. Schell	Foothills Vocational Center
Ralph Kneisley	Greenville Technical College, Department Head, Welding

The cooperation of these instructors and others representing The School District of Greenville County and Greenville Technical College is appreciated.

ABSTRACT

Title of Project: Occupational Education Articulation Program: Welding

Project Coordinator: Wm. Edward Henderson Jr.

Contracting Agency: The School District of Greenville County
P. O. Box 2848 - 301 Camperdown Way
Greenville, SC 29602

Program Period: March 1, 1982 through February 28, 1983

PURPOSE: To develop a continuous line of vocational training in similar Welding programs so that students may continue their education at the secondary and post-secondary levels without loss of time or waste of effort in repeating tasks that have been mastered previously.

To provide a system where teachers can cooperate effectively in providing a continuous occupational development program where the level and type of training that leads to entry-level employment skills will be clear to students, teachers, other educators, and employers.

METHOD: Welding instructors from two secondary level vocational centers of The School District of Greenville County and a post-secondary level welding program representative from the Industrial Division, Greenville Technical College were brought together in task force committee meetings and workshops to survey very similar vocational courses of training to identify possible overlap or gaps as students continued welding training from the secondary level to the post-secondary level. In addition, there was interest in lateral articulation of similar programs at the secondary level. Articulated, performance-based (competency-based) instruction objectives guides were developed by the Task Force Committee on Welding to facilitate articulation. By the task analysis process, the Task Force Committee on Welding, identified the essential competencies in Welding for a student to continue training or for initial entry into the labor market in a Welding related field. Major objectives for competency were stated, performance actions to obtain the objectives were identified and placed in sequencial order, instruction time was estimated, and performance standards for competency were stated. Finally, sample outcome-referenced (criterion-referenced) measures of competence were developed.

RESULTS: As a result of this project, the Articulated, Performance-based Instruction Objectives Guide for Welding, was developed. This articulation guide, however, is not a final product since it must be field tested and revised. Modifications and improvements to the Guide are expected since the process of education must be continually reviewed to ensure that objectives are valid and are being met as best they can be met under given conditions.

A Policies and Procedures Guide to aid articulation activities was developed in an earlier phase of the project and has been used to guide activities in the articulation of welding training. Two workshop guides, developed during the earlier phase of the project were used to assist task force committee participants in writing performance-based objectives, performance actions to reach the objectives, performance standards, and outcome-referenced tests. These guides include how-to-do-it sections distributed to teacher participants. The workshop guides and the Policies and Procedures Guide were revised during this phase of the articulation program based on field trial experience.

CONTENTS

Welding I 1

Welding II 3

Secondary Description 4

Post-Secondary Description 5

Post-Secondary Welding Credit 8

Scope of Articulation 9

Guide Organization Notes. 10

Sample Outcome-References Test. 11

Suggested Instruction Time 12

Orientation 16
Orientation 17

Welding Safety 18

Suggested Instruction Time. 19

Task Listings 20

Welding Safety 21
Safety: General 21
Classroom Safety 22
Apply Fire Safety Rules and Procedures 24
Apply Electrical Safety Rules and Procedures 25
Personal Safety In Welding 26
Safe Practices in Welding 28
Student Safety Pledge Form 31

Welding Math 32

Suggested Instruction Time. 33

Task Listings 34

Welding Math 35
Basic Math Review - Fractions 35
Basic Math Review - Decimals 36
Basic Math Review - Volumes 37
Basic Math Review - Areas 38
The Metric System 39

Measuring 41

Suggested Instruction Time. 42

Task Listing 43

Measuring 44
Measuring in Welding 44

Oxyacetylene Cutting/Welding 48

Suggested Instruction Time. 51

Task Listings 52

Oxyacetylene 55
Oxyacetylene Cutting/Welding Terminology 55
Oxyacetylene Cutting/Welding Safety 59
Perform Soap and Water Test (Safety) 61
Identifying Oxygen and Acetylene Gases and Cylinder Handling 62
Set up Oxyacetylene Cutting/Welding Station 63
Clean Oxyacetylene Cutting/Welding Tips 66
Lighting the Torch 67
Adjusting Flame 68
Oxyacetylene Cutting 69
Preparing the Joint 71
Carrying the Puddle (Fuse) 72
Run a Bead With Filler Rod 74
Weld Open Butt Joint, All Positions. 75
Weld T-Joint, All Positions. 76
Fillet Weld, Lap Joint, Flat and Overhead Positions. 78
Weld Corner Joint (Outside) Flat Position 79
Construct Pipe Weld in Fixed Position. 80
Braze Mild Steel 81

Arc Welding 83

Shielded Metal Arc Welding (SMAW) 84

Suggested Standards For Welding Training. 85

Welder Qualifications: Position and Type Limitations 86

Supplement to Standards 87

Suggested Instruction Time. 88

Task Listings 89

Note (For Tasks using 1/8 inch E7018 Electrode) 91

Arc Welding 92
Introduction (Principles) of Arc Welding 92
Safety in Arc Welding 98
Machines and Accessories 102
Select Electrode 105
Striking and Maintaining (Substaining) an Arc (Flat Position) 107
Chip Slag Using Chipping Hammer 115

Run Short Beads, Flat Position (Training Task) 116
Run Continuous Beads, Flat Position (Training Task). 117
Weld Weave Bead Pattern 119
Prepare Joint 121
Set Up and Make Stringer Beads on Flat Plate in All Position (Dual Task Description) (E6010 and E7018 Electrodes) 128
Set Up and Tack Weld Joints: Butt, Tee, Lap, and Corner Joints (Dual Task Description) 130
Set Up and Multi-Pass Weld T-Joint, All Positions (Multi-Task Description) 131
Construct Open Butt Weld, All Positions 134
Construct Lap Joint Weld, 3/8 Inch Equal Legs, Three Passes 135
Construct an Outside Corner Weld in the Vertical Up and Down Positions 136
Construct Groove Weld on Pipe in Flat Axis, Vertical, and Diagonal Axis Positions 137

Operating Gas Metal Arc Welding Equipment 139

Suggested Instruction Time. 142

Task Listings 143

Operate Gas Metal Arc Welding Equipment 145
Introduction to GMAW Welding 145
GMAW Welding Safety 148
Set Up and Shut Down GMAW (MIG) Equipment 149
Maintain Gas Metal Arc Welding Gun (Torch) 152
Weld Stringer Beads With GMAW Equipment, Flat Position 154
Weld Carbon Steel With GMAW Equipment Butt Joint, All Positions 155
Weld Carbon Steel, T-Joint, With GMAW Equipment, Flat and Vertical Positions (Up/Down) 156
GMAW Weld Pipe in Fixed Position(s), Downhill 157

Gas Tungsten Arc Welding 159

Suggested Instruction Time. 161

Task Listings 162

Gas Tungsten Arc Welding 164
Introduction to (GTAW) Welding 164
(GTAW) Safety 165
Prepare for GTAW Welding, Startup Equipment, Adjust, Shut-down 166
Disassemble and Clean GTAW (TIG) Torch Assembly 169
Carrying the Puddle 170
Weld Stringer Beads, Mild Steel, and Flat Position, Using GTAW Equipment 171
Weld Carbon Steel With GTAW (TIG) Equipment, All Positions 172

Weld Stainless Steels With GTAW (TIG) Process, All Positions 173

Weld Aluminum or Aluminum Alloys With GTAW (TIG) Equipment, Flat, T, and Open Butt 175

Weld Testing 179

Suggested Instruction Time. 180

Task Listings 181

Weld Testing 182
Make Guided Bend Test of Butt Joint (Optional) 182
Test Fillet Welded Joint (Optional). 184
Conduct Visual Inspection. 185

Blueprint Reading 186

Suggested Instruction Time. 187

Task Listings 188

Blueprint Reading 189
Identify Information 189
Visualize Objects From Multi-view Drawings 191
Determine Specification. 192

Proficiency Report 194

Illustration of GTC Exemption Testing 199

References. 204

APPENDIXES

Appendix A	Tasks Not Addressed
Appendix B	Joint Articulation Agreement
Appendix C	Instructor's Signed Agreement to Articulate
Appendix D	Philosophy of Articulation Guide Design
Appendix E	Purposes of Articulation Guide
Appendix F	Definitions of Terms
Appendix G	Directions for Tests
Appendix H	Responsibility Sheet
Appendix I	Binder Design

WELDING I

LEVEL: Secondary

TITLE: Welding I

DESIGNATION: WELDING I COMPUTER NUMBER: 773

DESCRIPTION: Welding is designed to qualify students with the knowledge and skills necessary for successful entry level employment in the welding field. Welding instruction includes blueprint reading, characteristics of various metals, and methods of testing welds. Laboratory demonstrations and experience include both arc welding and gas welding practices. Cutting, brazing special welding processes, and safety are taught also.

OBJECTIVES: Plans a sequence of welding operations, select equipment to be used or parts of metal involved to accomplish a job.

Inspects welds and tests welded joints of work in progress and of completed work for visible defects, correct dimensions, joint strength, bead, weld penetration, and conformance to specifications, applying knowledge of geometry, welding principles, and physical properties of metals.

Connects hose from hand torch to oxygen and fuel tanks, or connects cables from power source to electrode holder to set up welding equipment.

Adjusts valves on gas tanks to start flow of gases in hand torch, and adjusts mixture and pressure of gas welding equipment to obtain flame of desired size and color to weld metal parts.

Uses arc or flame cutting to cut metal plates and structure shapes from metal stock.

PERFORMANCE EVALUATION: Given basic welding tools and equipment, the necessary specifications, sketches, or blueprints, the student will demonstrate mastery of welding equipment, tools, and operations to produce acceptable metal products or make repairs.

Through outcome-referenced measures, the student will demonstrate competency in knowledge and skills necessary

to successfully enter welding employment or to qualify for further advanced training such as in pipe welding at the post-secondary level.

JOB QUALIFICATION: Welders are qualified to read and interpret blueprints and drawings, to plan a sequence of operations, select the necessary equipment and materials, and apply simple mathematics to produce welded products or make welded repairs.

Welders apply heat from gas or electric sources to melt metal pieces to form a permanent bond with or without the use of filler metal.

Welders may use oxyacetylene or arc cutting to trim metal to desired sizes or shapes.

A combination welder can perform both electric and gas welding, according to layouts or work orders. Combination welders fabricate metal products, repair broken or cracked metal parts, fill or increase the size of metal parts.

Typical D.O.T. classifications for welding are:

Welder, Combination	812.884-014
Welder, Combination Apprentice	812.884-010
Welder, Production Line	812.884-018
Welder, Repair	812.884-022

Welder, Arc D.O.T. 810.884, T.E.A. 17.23 32
Welder, Gas D.O.T. 811.884, T.E.A. 17.23 32

WORKING CONDITIONS: Welding involves manual dexterity, welding requires good hand coordination and the ability to concentrate on detailed work for a long period of time. Welders may have to lift moderate weights of metal or equipment in their work of may have to stoop and work in a crouched position for long periods.

Some disadvantages found in welding work are occasional burns from welding sparks, exposure to fumes from molten metals, noxious or offensive odors, and work in outside cold or enclosed hot environments.

Welders must use protective equipment and safety procedures to avoid serious burns, injuries to the eyes, and explosions.

PREREQUISITES: None

For optimum success, welders should have manual dexterity, eye-hand coordination, color discrimination, and be in good physical condition. Some proficiency in mathematics and mechanical drawing would be helpful.
Suggested Grade Level: 11

REQUIRED/SUGGESTED INSTRUCTIONAL HOURS:

System	Year		
Division	Class	Lab	Total
Credits	3	-	3
Hours	540	-	540

LEVEL: Secondary

TITLE: Welding II

DESIGNATION: WELDING II COMPUTER NUMBER: 774

DESCRIPTION: Welding II is a continuation of training and reviews, expands, and applies those principles learned in Welding I.

OBJECTIVES: Same objectives as Welding I. Performs welding practices with greater knowledge and skill.

PREREQUISITES: Welding I

Suggested Grade Level: 12

REQUIRED/SUGGESTED INSTRUCTIONAL HOURS:

System	Year		
Division	Class	Lab	Total
Credits	3	-	3
Hours	540	-	540

SECONDARY DESCRIPTION

WELDING

Welding includes the study of the weldability of metals, the physical properties of metals, and the testing of welded joints. A graduate of the welding program will have knowledge and skills in electric arc welding, oxyacetylene welding, heating, cutting, and brazing of common metals.

Graduates of welding training should be competent to satisfactorily enter the welding occupation and progress from apprentice to certified welder.

Recommended course content (SC State Department of Education):

Electric

1. Safety
2. Terminology
3. Identification of metals
4. Principles of arc welding
5. Welding symbols
6. Electrodes
7. Striking an arc and travel
8. Position welding:
   - Flat
   - Horizontal
   - Vertical
   - Overhead
9. Cutting
10. Pipe welding
11. Planning and estimation
12. Special welding processes

Oxyacetylene

1. Filler rods and fluxes
2. Flame adjustment
3. Heating
4. Setting up gas welding equipment
5. Flame cutting
6. Brazing

Outline of High School Credit Courses, Columbia, SC: State Department of Education, pp. 141-142, 1980, (with local update/modification).

POST-SECONDARY DESCRIPTION

WELDING

The post-secondary welding program is a four quarter diploma program. Students may enter each quarter either day or night. Those with prior credits may progress into the more advanced classes.

Suggested Sequence of Required Courses (4/82):

FIRST QUARTER

COURSE NUMBER	COURSE TITLE	CLASS	LAB	CREDIT
WLD 113	Gas and/or Arc Welding T & P	5	15	10
WLD 139	Testing of Welded Joints	2	0	2
ENG 126	Communications I	3	0	3
EGT 100	Blueprint Reading and Sketching	3	0	3
		13	15	18

SECOND QUARTER

WLD 123	Arc Welding T & P I	5	15	10
WLD 122	Properties, Testing and Treatment of Metals	5	0	5
MAT 112	Applied Math I	5	0	5
		15	15	20

THIRD QUARTER

WLD 120	Gas and Inert Welding T & P	5	15	10
WLD 144	Burning and Fitting Pipe Joints I	4	0	4
ECO 100	Consumer Economics	3	0	3
		12	15	17

FOURTH QUARTER

WLD 146	Advanced Welding	5	15	10
WLD 154	Burning and Fitting Pipe Joints II	4	0	4
PSY 112	Industrial Human Relations	3	0	3
		12	15	17

ELECTIVE

WLD 141	Qualification Welding	4	3	5

Source: Ralph Kneisleg, Department Head, Welding, Greenville Technical College, April 1982.

POST-SECONDARY COURSE DESCRIPTION

WELDING

(1982 New Courses not included)

WLD 120 GAS & INERT WELDING T & P

"An introduction to welding using the oxacetylene method in the four basic positions, to include pipe welding, brazing, and flame cutting. Safe handling of equipment will be emphasized. Similarities of this method and TIG welding will be shown. Above procedures, but to include stainless steel and non-ferrous metals, will be practiced with the TIG process. (5-15-10)

WLD 123 ARC WELDING T & P I

"Will consist of the principles and practice of arc welding on ferrous and non-ferrous metals. The student will be able to set the correct machine setting, maintain the proper care of machines and equipment, and use safe practices and procedures in different positions. Pre-requisite: WLD 120 (5-15-10)

EGT 100 BLUEPRINT READING AND SKETCHING

"A study of basic blueprint reading and sketching. It includes a detailed study of layout, projection, and dimensioning. The student completing this course should be able to make sketches of certain geometric shapes and be able to orthographically project these shapes. He should be able to read and interpret shop drawings, and should be familiar with the most common drawing instruments. (3-0-3)

WLD 146 ADVANCED WELDING

"A continuation of arc, gas and inert welding. The student will be perfecting his techniques in his selected type of welding. Prerequisite: WLD 123 (5-15-10)

WLD 122 PROPERTIES, TESTING, & TREATMENT OF METALS

"Covers methods of manufacturing steel, the modern blast furnace, cast iron, mallable iron wrought iron, steel, open hearth furnace, Bessemer furnace, the electric furnace, and the crucible furnace; the manufacture of stainless steel, manufacture of brass and bronze, aluminum and zinc and shaping of metals. The student will study the physical and chemical properties of the different properties of metals, such as steel, cast iron, brass, stainless steel and aluminum. (5-0-5)

WLD 211 ADVANCED WELDING I

"Advanced training in inert gas and shielded metal arc processes. Prerequisite: WLD 146 (5-15-10)

MAT 169 APPLIED MATH - WELDING

"Mathematical applications as applied to welding. (5-0-5)

WLD 139 TESTING OF WELDED JOINTS

"Covers both destructive and non-destructive testing of welded joints. The student will be able to conduct guided bend tests. (2-0-2)

WLD 144 BURNING & FITTINGS PIPE JOINTS I

"The student will be taught structural joint design and layout; the making and use of templates for pipe and tubing, pipe symbols, pipe code welding and basic estimating procedures. (4-0-4)

WLD 154 BURNING & FITTING PIPE JOINTS II

"A continuation of Welding I including more advanced training in pipe welding and soldering tubing. Flame cutting will be included. (4-0-4)

Industrial Division, Greenville Technical College, Greenville, SC: Greenville Technical College, pp. 53, 59-60, 1980-82.

POST-SECONDARY WELDING CREDIT

BY EXAMINATION

Post-secondary welding course exemption is by "Credit Examination" administered by the Welding Department, Green[illegible]lle Technical College, at a charge of $15.00 per exam.

SCOPE OF ARTICULATION

WELDING

(Similar Training)

Welding articulation is based on close cooperation between instructors and the possibility of considerable overlap in training between secondary and post-secondary welding programs.

To exempt post-secondary welding training, secondary graduates should present an official "Welding Proficiency Report" to the post-secondary welding department head as a summary of demonstrated competencies, receive the recommendation of the (former) secondary welding instructor, and must successfully pass required "Credit Examination" Welding Tests administered by the Welding Department, Greenville Technical College, at a charge of $15.* Post-secondary welding placement testing is considered essential to determining the appropriate level of training for secondary graduates who already have demonstrated some welding competency.

*Effective February, 1983, subject to change.

GUIDE ORGANIZATION NOTES

OPTIONAL TASKS

"Optional" tasks are labeled to indicate that secondary instructors agree that the task is important and should be included in training provided the training budget allows for adequate expendible supplies such as welding rods, gases, or base metals and provided the tasks meet student needs.

ORIENTATION TASKS

Tasks labeled "orientation" indicate that training basically is of an orientation or introductory nature and, typically, competency is not obtained as a result of secondary training.

SAFETY TRAINING

While welding safety is described at the beginning of the articulated guide and in major units of instruction, safety is integrated throughout the entire course of training on a daily basis.

TERMINOLOGY

Competency in welding terminology typically is not mastered until the end of the unit or course training period.

SUGGESTED INSTRUCTIONAL TIME

Suggested instructional hours for welding are for planning purposes only. The actual hours will depend on the availability of expendible training materials such as welding rods, gases, and base metals as well as the time necessary for the student to demonstrate the minimum suggested competencies. Suggested instructional time is based on the average student in an average instructional situation.

GUIDE DESCRIBES MINIMUM STANDARDS

The Articulated, Performance-based Instruction Guide for Welding describes the suggested "minimum competencies" for a secondary welding student. Secondary welding students will be encouraged to exceed the "minimum standards."

SAMPLE
OUTCOME-REFERENCED TESTS

WELDING

This articulated, performance-based instruction guide is designed to answer three critical questions necessary for quality instruction.

First, what should be taught?

The objectives of the articulated, performance-based education - vocational education program are based on extensive task analysis and validation.

The task objectives represent what employers in business and industry say is important for entry level job success.

Second, how should it be taught?

It should be taught using the latest "state-of-the-art" instructional technology incorporated into each unit.

Students are taught the knowledges, skills, and attitudes needed for successful and productive employment.

Third, how should students be evaluated?

Students are evaluated using a validated competency-based approach to determine student proficiency vocational knowledges and skills.

The minimum standards are those required for successful entry in the next high level of training or for succesful employment.

The sample tests are included to illustrate how the student's competency in vocational skills and knowledges may be measured with validity and reliability. In addition, the test samples are included to promote standardization in the evaluation of vocational students in similar programs.

Test items have been constructed solely from the objectives of the vocational program. The statement of the objectives indicate the level of knowledge or skill to be tested. Task force committee participants have attempted to write tests that agree with objectives in the behavior requested, the given conditions, and the desired standards of performance.

NOTE: Unless the test page is marked "Revised" or "R," the test should be considered a field trial edition currently under review and revision.

WELDING

SUGGESTED INSTRUCTION TIME

WELDING UNIT/TASK		SUGGESTED HOURS
Unit 0.0		
0.0	Orientation	1
Unit 1.0		
1.01	Safety: General	2
1.02	Classroom Safety	1
1.03	Apply Fire Safety Rules and Procedures	1
1.04	Apply Electrical Safety Rules and Procedures	1
1.05	Personal Safety in Welding	2
1.06	Safe Practices in Welding	6
Unit 2.0		
2.01	Basic Welding Math - Fractions	6
2.02	Basic Welding Math - Decimals	6
2.03	Basic Welding Math - Volumes	1
2.04	Basic Welding Math - Areas	1
2.05	The Metric System	1
Unit 3.0		
3.01	Measuring in Welding	6
Unit 4.0		
4.01	Oxyacetylene Cutting/Welding Terminology	N/A
4.02	Oxyacetylene Cutting/Welding Safety	20
4.03	Perform Soap and Water Test (Safety)	***

4.04	Identifying Oxygen and Acetylene Gases and Cylinder Handling	4-6
4.05	Set Up Oxyacetylene Cutting/Welding Station	3
4.06	Clean Oxyacetylene Cutting/Welding Tips	1-2
4.07	Lighting the Torch	9-15
4.08	Adjusting Flame	**4.07
4.09	Oxyacetylene Cutting	**4.07
4.10	Preparing the Joint	3
4.11	Carrying the Puddle (Fuse)	4-6
4.12	Run a Bead With Filler Rod	6
4.13	Weld Open Butt Joint, All Positions*	45
4.14	Weld T-Joint, All Positions*	20
4.15	Fillet Weld, Lap Joint, Flat and Overhead* Positions	4
4.16	Weld Corner Joint (Outside) Flat Position	2
4.17	Construct Pipe Weld in Fixed Position	*
4.18	Braze Mild Steel	*
Unit 5.0		
5.01	Introduction (Principles) of Arc Welding	6
5.02	Safety in Arc Welding	6
5.03	Machines and Accessories	15
5.04	Select Electrode	4-6
5.05	Striking and Maintaining (Substaining) an Arc (Flat Position)	15
5.06	Chip Slag Using Chipping Hammer	1
5.07	Run Short Beads, Flat Position (Training Task)	160
5.08	Run Continuous Beads, Flat Position (Training Task)	**5.07

5.09	Weld Weave Bead Pattern	**5.07
5.10	Prepare Joint	4-6
5.11	Set Up and Make Stringer Beads on Flat Plate in All Positions (Dual Task Description) (E6010 and E7018 Electrodes)	185
5.12	Set Up and Tack Weld Joints: Butt, Tee, Lap, and Corner Joints (Dual Task Description)	185
5.13	Set Up and Multi-Pass Weld T-Joint, All Positions (Multi-Task Description)	185
5.14	Construct Open Butt Weld, All Positions	*
5.15	Construct Lap Joint Weld, 3/8 Inch Equal Legs, Three Passes	*
5.16	Construct an Outside Corner Weld in the Vertical Up and Down Position	*
5.17	Construct Groove Weld On Pipe In Flat Axis, Vertical, and Diagonal Axis Positions	*

Unit 6.0

6.01	Introduction To GMAW Welding	3
6.02	GMAW Welding Safety	2
6.03	Set Up and Shut Down GMAW (MIG) Equipment	2
6.04	Maintain Gas Metal Arc Welding Gun (Torch)	2
6.05	Weld Stringer Beads With GMAW Equipment, Flat Position	3
6.06	Weld Carbon Steel With GMAW Equipment Butt, Joint, All Positions	*
6.07	Weld Carbon Steel, T-Joint, With GMAW Equipment, Flat and Vertical Position (Up/Down)	6
6.08	GMAW Weld Pipe in Fixed Position(s), Downhill	*

Unit 7.0		
7.01	Introduction To (GTAW) Welding	3
7.02	(GTAW) Safety	2
7.03	Prepare for GTAW Welding, Startup Equipment, Adjust, Shut-down	1
7.04	Disassemble and Clean GTAW (TIG) Torch Assembly	1
7.05	Carrying The Puddle	4-6
7.06	Weld Stringer Beads, Mild Steel, and Flat Position, Using GTAW Equipment	2
7.07	Weld Carbon Steel With GTAW (TIG) Equipment, All Positions	20-30
7.08	Weld Stainless Steels With GTAW (TIG) Process, All Positions	*
7.09	Weld Aluminum or Aluminum Alloys With GTAW (TIG) Equipment, All Positions	40-50
Unit 8.0		
8.01	Make Guided Bend Test of Butt Joint (Option)	*
8.02	Test Fillet Welded Joint	*
8.03	Conduct Visual Inspection of Weld	
Unit 9.0		
9.01	Identify Information	25-30
9.02	Visualize Objects From Multiview Drawings	*
9.03	Determine Specifications	*
	TOTAL	1,080

*Hours not specified, integrated or optional task.
**Conducted jointly with task indicated.

UNIT 0.0

ORIENTATION

UNIT	0.0	WELDING I
TASK	0.0	ORIENTATION

PERFORMANCE OBJECTIVE:

Given information on school policies and procedures, apply these policies and procedures. The policies and procedures will be adhered to on a day-to-day basis. Meet standards of the instructor 100 percent.

PERFORMANCE ACTIONS:

1. Review with instructor school policies and procedures.
2. Review with instructor philosphy of school and state.
3. Review with instructor course objectives for Welding (Welding I or Welding II).
4. Review with instructor shop (classroom) policies and procedures, etc.

PERFORMANCE STANDARDS:

- Apply information/instructions given during orientation and throughout training period to comply with all policies and procedures on a day-to-day basis.
- The standards of the state, school district, school, and instructor will be met 100 percent.

SUGGESTED INSTRUCTION TIME: 1 Hour

UNIT 1.0

WELDING SAFETY

WELDING
SAFETY
SUGGESTED INSTRUCTION TIME

SAFETY UNIT/TASK		SUGGESTED HOURS
Unit 1.0		
1.01	Safety: General	2
1.02	Classroom Safety	1
1.03	Apply Fire Safety Rules and Procedures	1
1.04	Apply Electrical Safety Rules and Procedures	1
1.05	Personal Safety in Welding	2
1.06	Safe Practices in Welding	6

TASK LISTINGS
WELDING I
WELDING SAFETY

UNIT/TASK	DESCRIPTION
Unit 1.0	
1.01	(Safety: General) Given an orientation to building, shop, and fire safety; discuss, identify, or demonstrate general shop safety behavior and fire safety procedures.
1.02	(Classroom Safety) Given a typical welding shop/classroom or work situation, exhibit an awareness of safety practices, safe work habits, and a positive attitude concerning welding safety and accident prevention and meet the standards established by the instructor.
1.03	(Apply Fire Safety Rules and Procedures) Given examples of types of fires, fire extinguishers, and possible shop situations, apply fire safety rules and procedures. Meet National and local fire safety procedures.
1.04	(Apply Electrical Safety Rules and Procedures) Given orientation to identifying electrical hazards, apply electrical safety rules and procedures. Electrical equipment, exposed wire, frayed cables, and deteriorated insulation must be reported and corrected. Proper grounding must be employed and maintained. Junction boxes, outlets, switches, breaker switches, and panels must be identified as to their use. Meet all applicable National and local standards and the standards of the instructor.
1.05	(Personal Safety in Welding) Given a list of protective equipment used in welding, identify what each item is used with 100 percent accuracy by the end of the instruction unit. As applicable, demonstrate proper use of safety equipment.
1.06	(Safe Practices in Welding) NOTE: This objective will be repeated in each unit (ARC, Oxy-fuel, etc.) of welding to clarify the safe practices that must be followed when performing various tasks in welding. Given an orientation, resource books and information, machine information (identification plates, etc.), and shop/lab posters, etc., follow accepted practices in welding as outlined by the instructor, the textbooks, manufacturer's identifications on machines, etc.

UNIT	1.0	WELDING I
TASK	1.01	SAFETY: GENERAL

PERFORMANCE OBJECTIVE:

Given an orientation to building, shop, and fire safety; discuss, identify, or demonstrate general shop safety behavior and fire procedures.

PERFORMANCE ACTIONS:

1.0101 As applicable, discuss basic safety rules applicable to the training facility.

1.0102 Identify general shop safety rules.

1.0103
a. Review with the instructor fire safety rules.
b. Identify fire safety equipment, exits, and procedures in the shop and building area during a fire.

PERFORMANCE STANDARDS:

- Follows basic safety rules and established shop safety practices.
- Follows established fire safety practices and procedures.

SUGGESTED INSTRUCTION TIME: 2 Hours

UNIT	1.0	WELDING I
TASK	1.02	CLASSROOM SAFETY

PERFORMANCE OBJECTIVE:

Given a typical welding shop/classroom or work situation, exhibit an awareness of safety practices, safe work habits, and a positive attitude concerning welding safety and accident prevention and meet standards established by the instructor.

PERFORMANCE ACTIONS:

1.0201 Develop an awareness of hazards and become more safety conscious.

1.0202 Develop a serious attitude toward the use of safety procedures.

1.0203 Prepare for safety before entering the work area.

1.0204 Prepare for safety on entering the work area.

1.0205 Prepare for safety at the work station.

1.0206 Demonstrate knowledge of safety color coding and symbols.

1.0207 Practice safe procedures.

1.0208 Prepare for safety on leaving the work environment.

PERFORMANCE STANDARDS:

- "Zero-Level" accident record.
- Standards acceptable to the instructor based on recommended resources.

SUGGESTED INSTRUCTION TIME: 1 Hour

RECOMMENDED RESOURCES:

Consult current District Safety Guide.

Jacobs, Clinton O., and Howard J. Turner, Developing Shop Safety Skills, Athens, GA: American Association for Vocational Instructional Materials. Approximately 80 pages of brief, visually clear suggestions concerning a variety of shop safety situations. Good student or resource manual.

RECOMMENDED RESOURCES (Con't.):

Safety Handbook, A Guide for Trade and Industrial Programs, Clemson University, SC: Vocational Education Media Center, 1968. (No. 13/2/70, $2.25: Accompanying 31 Transparencies, No. 9/8/68, $5.75.) Available from Trades and Industries District Supervisors, Office of Vocational Education, South Carolina State Department of Education or from the Vocational Education Media Center, Clemson University, SC.

Planning for Emergencies, Occupational Safety and Health Short Course Number Seven, Columbia, SC: SC State Board for Technical and Comprehensive Education.

Notgrass, Troy, Safety Handbook for ICT, The University of Texas at Austin: Center for Occupational Curriculum Development, Division of Continuing Education, 1978.

RELATED TECHNICAL INFORMATION:

- Regulations of individual school or classroom.
- Regulations of The School District of Greenville County.
- Codes, laws, and ordinances.
- Materials and equipment handbooks and manuals.
- OSHA Regulations.
- E.P.A. Regulations.

UNIT	1.0	WELDING I
TASK	1.03	APPLY FIRE SAFETY RULES AND PROCEDURES

PERFORMANCE OBJECTIVE:

Given examples of types of fires, fire extinguishers, and possible shop situations, apply fire safety rules and procedures. Meet National and local fire safety procedures.

PERFORMANCE ACTIONS:

1.0301 Identify and explain application for:
- a. foam
- b. carbon dioxide
- c. soda acid
- d. pump tank
- e. gas cartridge
- f. dry chemical
- g. multi-purpose dry chemical fire extinguishers

1.0302 Describe procedures for operating selected fire extinguishers.

1.0303 Identify common causes of fire in welding shop and common methods for avoiding or preventing fires.

1.0304 Inspect shop/laboratory for conformity with fire safety rules and procedures.

1.0305 Identify/explain relevant safety precautions for welding.

PERFORMANCE STANDARDS:

- Apply fire safety rules and procedures in welding meeting all applicable standards, National and local, and meeting instructor's standards.

SUGGESTED INSTRUCTION TIME: 1 Hour

UNIT	1.0	WELDING I
TASK	1.04	APPLY ELECTRICAL SAFETY RULES AND PROCEDURES

PERFORMANCE OBJECTIVE:

Given orientation to identifying electrical hazards, apply electrical safety rules and procedures. Electrical equipment, exposed wire, frayed cables, and deteriorated insulation must be reported and corrected. Proper grounding must be employed and maintained. Junction boxes, outlets, switches, breaker switches, and panels must be identified as to their use. Meet all applicable National and local standards and the standards of the instructor.

PERFORMANCE ACTIONS:

1.0401 Explain importance of labeling circuit breakers.

1.0402 Explain importance of proper grounding on welding machines and equipment.

1.0403 Demonstrate/explain methods for using flexible extension cords, long cables, and drop lights.

1.0404 Identify electrical hazards and explain safety rules and procedures pertaining to welding, cutting, and brazing.

1.0405 Identify approved locations for all electrical equipment and power sources in the welding shop.

1.0406 Interpret safety precautions for electricity in the welding shop.

PERFORMANCE STANDARDS:

- Apply electrical safety rules and procedures for the welding shop/laboratory on a day-to-day basis meeting all applicable National and local safety rules and regulations and the standards of the instructor.

SUGGESTED INSTRUCTION TIME: 1 Hour

UNIT	1.0	WELDING I
TASK	1.05	PERSONAL SAFETY IN WELDING

PERFORMANCE OBJECTIVE:

Given a list of protective equipment used in welding, identify what each item is used for with 100 percent accuracy by the end of the instruction unit. As applicable, demonstrate proper use of safety equipment.

PERFORMANCE ACTIONS:

1.0501 List and explain the rules for personal safety.

1.0502 Identify each item for protective equipment used in welding from a given list, sketch, or mock-up.

PERFORMANCE STANDARDS:

- Given a list, sketch, or mock-up, identify with 100 percent accuracy personal protective equipment used in welding.

SUGGESTED INSTRUCTION TIME: 2 Hours

RELATED TECHNICAL INFORMATION:

- Select proper lens shade for welding job.

SELECT PROPER SAFETY LENS

LENS SHADE SELECTOR

Type of operation	Shade number
Soldering	2
Torch brazing	3 or 4
Oxygen cutting	
0 - 1 inch	3 or 4
1 - 6 inches	3 or 5
6 inches and over	5 or 6
Gas welding	
0 - 1/8 inch	4 or 5
1/8 to 1/2 inch	5 or 6
1/2 inch and over	6 or 8
Shielded metal arc welding	
1/16, 3/32, 1/8, 5/32 inch electrodes	9 - 14
Gas Metal Arc Welding	
Gas tungsten arc welding	9 - 14
Nonferrous, gas metal arc welding	
1/16, 3/32, 1/8, 5/32 inch electrode	
Gas tungsten arc welding (ferrous),	9 - 14
gas metal arc welding (ferrous)	
1/16, 3/32, 1/8, 5/32 inch electrodes	

UNIT 1.0 WELDING I

TASK 1.06 SAFE PRACTICES IN WELDING

PERFORMANCE OBJECTIVE:

NOTE: This objective will be repeated in each unit (ARC, Oxy-fuel, etc.) of welding to clarify the safe practices that must be followed when performing various tasks in welding. Given an orientation, resource books and information, machine information (identification plates, etc.), and shop/lab posters, etc.; follow accepted practices in welding as outlined by the instructor, the textbooks, manufacturer's identifications on machines, etc.

PERFORMANCE ACTIONS:

1.0601 Identify major areas of safe practice in oxy-fuel, ARC, MIG, and TIG welding as well as working with metals including the use of hand and power tools.

1.0602 Apply safe practices on a day-to-day basis in working with or welding metals and in using equipment in the welding shop/lab.

PERFORMANCE STANDARDS:

- Apply safe practices on a day-to-day basis in operating welding machines, working with or welding metals, and in using equipment in the welding shop/lab.
- Manufacturer's standards, accepted practices of the trade, and the instructor's standards apply.

SUGGESTED INSTRUCTION TIME: 6 Hours

SAFETY PRACTICES RECOMMENDED FOR WELDING

1. Always wear suitable protective clothing.
2. Maintain a safe, clean work area.
3. Do not weld near flammable materials.
4. Do not weld in the vicinity of explosive materials or near carbon tetrachloride.
5. Do not weld in an area with less than three or four complete changes of air per hour.
6. Use air exhaust at the weld whenever welding lead, cadmium, chromium, manganese, brass, bronze, zinc, or galvanized metals.
7. Never weld or cut in a confined area without proper safety precautions.
8. Handle inert gas cylinders with the same care you use with oxyacetylene cylinders.
9. Keep all welding equipment in good condition.
10. If it is necessary to couple lengths of cable together, make sure joints are insulated and all electrical connections are tight; use no cables with frayed, cracked, or bare spots.
11. When an electrode holder is not in use, hang it on welding machine or in special holder; never let it touch a gas cylinder.
12. Always have the welding machine properly grounded.
13. Use guard on pedal controls to prevent accidental starts.
14. If need arises to weld in damp or wet conditions, wear rubber boots and/or stand on dry cardboard or wood.
15. Stand only on solid items, floor, or ground.
16. When welding in high places without railings, use safety belt or lifeline.
17. Wear proper eye protection, especially when grinding or cutting.
18. Take necessary steps to protect the eyes of others.
19. Never weld or cut directly on a concrete floor.
20. When using a water-cooled torch, check for water leakage.
21. Do not use oil or grease on any oxygen or acetylene connections as oil and oxygen will ignite.
22. Never open tank valves until you are certain that regulator valves are closed.
23. Never open the valves on the cylinders with a hammer.
24. Never hammer on oxygen or acetylene regulators.
25. Do not light a torch with a match or open flame; use spark striker provided.
26. Before lighting torch, be positive that hose, tanks, or any inflammable materials will not be exposed to heat, flame, or sparks.
27. Beware of high acetylene pressure; never use acetylene gas when the pressure is greater than 15 pounds per square inch.
28. Never screw the regulator screw in tight against the regulator as this spoils the diaphragm; if hose pressure drops, check tank pressure at regulator; tank is probably empty.
29. Do not hold welding or cutting tip too close to your work since this may cause a flash-back in the torch.

30. Never use a tip that gets hot.
31. Never use a torch that leaks.
32. Never leave your torch burning and go away from it.
33. Never leave torch valve open.
34. Do not use the torch for a hammer, crowbar, wedge, or for any other purpose than welding; do not use a cylinder, even when empty, as a roller.
35. Do not store cylinders in a room where the temperature is more than 80°.
36. Do not adjust, alter, change, build, or do any experimental work on cylinders, regulators, torches, or any other gas equipment.
37. Never attempt to weld a closed or jacketed tank, vessel, or container without a vent for air.
38. Report any defective tools, machines, or other equipment to the instructor.
39. Operate a hazardous machine only after receiving instruction on how to operate the machine safely.
40. Retain all guards and safety devices except with the specific authorization of the instructor.
41. Report all accidents to the instructor regardless of nature or severity.
42. Turn off the power before leaving a machine.
43. Make sure all guards and barriers are in place and adjusted properly before starting a machine tool.
44. Disconnect the power from machine tools before performing maintenance tasks.
45. Use correct, properly fitting tools for nuts, bolts, and fasteners to be turned or held.
46. Keep the shop or laboratory floor clear of scraps and litter.
47. Clean up any spilled liquids immediately.
48. Store oily rags or oily waste in metal containers.
49. Clean the chips from a machine with a brush—not with a rag or the bare hands.

SAFETY

STUDENT SAFETY PLEDGE FORM

_____, who is enrolled in Vocational Welding, will as a part of training, operate machines and equipment providing that the student's parent or guardian gives written permission.

It is understood that each student will be given proper instruction, both in the use of the equipment and in correct safety procedures concerning it, before being allowed to operate it. The student must assume responsibility for following safe practices, and therefore the student is asked to subscribe to the following safety pledge.

1. I promise to follow all safety rules for the shop.
2. I promise never to use a machine without first having permission from the instructor.
3. I will not ask permission to use a particular machine unless I have been instructed in its use, and have made 100% on the safety test for that machine.
4. I will report any accident or injury to the teacher immediately.

Date _____ Student's signature _____

I hereby give my consent to allow my son/daughter to operate all machines and equipment necessary in carrying out the requirements of Welding training.

Date _____ Parent's signature _____

Parents are cordially invited to visit the shop to inspect the machines and to see them in operation.

UNIT 1.0 - SAFETY

OUTCOME-REFERENCED TESTS

1. List five items of personal safety.

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____

2. List five safety practices for handling oxyacetylene equipment.

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____

3. When welding on cutting, brass, bronze, lead, cadnium, or beryllium, metal, it is especially important to

   _____ a. proper clothing
   b. use flash arresters
   c. proper ventilation
   d. wear ear protection

4. Beware of high acetylene pressure, never use acetylene gases when pressure is greater than _____.

   _____ a. 20 PSI
   b. 15 PSI
   c. 10 PSI
   d. 5 PSI

5. Proper eye protection must be used while welding because arc welding produces harmful

   _____ a. ultra-violet rays
   b. micro-vapors
   c. gamma rays
   d. infrared rays

6. When conducting cutting and grinding operations, it is extremely important to use

_____ a. eye protection
b. adequate time
c. electric grinder
d. leather shoes

7. What is the most common and most serious accident in the welding shop?

_____ a. bruses
b. burns
c. eye injury
d. cuts and scratches

COMPLETION

8. Never use _____ to ventilate a container.

9. The welder should use _____ or _____ to handle hot metal.

10. Welding equipment should never be worked on without permission of the _____.

11. There are three classes of "FIRES", Classes, "A", "B", and "C", fires, what types of fire is an electrical fire?

_____

TRUE-FALSE

12. _____ A fire extinguisher that has A- B- C- on the front of the unit, is suitable for all fires.

13. _____ Is it a normal practice for the welder to flame cut on a concrete floor?

14. _____ Is it good practice to use leather boots when welding in damp areas?

UNIT 1.0 - SAFETY

OUTCOME-REFERENCED TESTS

TASK 1.03

1. What kind of damage can be caused by intense visible rays similar to those given when an arc is stuck?

   _____

2. What kind of danger can strong ultra-violet rays cause?

   _____

3. What problems may result from continued exposure to infrared rays?

   _____

4. Explain the problems involved in healing serious burns by ultra-violet rays?

   _____

5. What is the condition of the eye when it has been injured by arc flash?

   _____

6. How do you treat minor burns in which the skin is not broken?

   _____

7. List seven things to remember when treating a person who has received major burns?

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____
   6. _____
   7. _____

UNIT 1.0 - SAFETY

OUTCOME-REFERENCED TESTS

Task 1.06

1. Why is removing all the combustibles often an unsatisfactory method of making a vessel safe for welding?

   _____

2. Describe the symptoms of lead poisoning?

   _____

3. What are the symptoms of metal fume fever?

   _____

4. What kind of healing problems may result from poisoning due to welding maganese and its alloys?

   _____

5. Name a metal that is used to coat another metal and that will give off deadly fumes when heated?

   _____

UNIT 1.0 - SAFETY

Answer Sheet

1. 1. 100% cotton (LS) shirt
   2. nonfraed clothing
   3. safety glasses
   4. ankle top leather shoes
   5. welding gloves

2. 1. crack the valve before installing regulators
   2. open cylinder valves only after thumb screws are out
   3. make sure cylinders are chained in place
   4. oxyacetylene hoses should be draped not hunged from carts
   5. use approved striker to light torches, not matches or lighters

3. c

4. b

5. a & d

6. a

7. c

8. oxygen

9. tongs, pliers

10. instructor

11. Class "C"

12. true

13. false

14. false

UNIT 1.0 - SAFETY

Task 1.03

Answer Sheet

1. Eyestrain and possible temporary blindness.

2. Severe inflammation, similar to sunburn.

3. Infrared rays may cause cumulative effects that may lead to cataracts or retina injuries.

4. The burns heal slowly and they can leave scar tissue which continues to be sensitive to both heat and cold.

5. The eyeball becomes covered with many small water blisters.

6. Put the affected part in cold water.

7. 1. Handle person only if necessary.
   2. Do not use salve or lotions on burns.
   3. Leave burned clothing on burn.
   4. Do not break blisters.
   5. Cover affected area with dry dressing.
   6. Use shock preventive treatment.
   7. Get medical help quickly.

TASK 1.06

1. It is a costly method not appropriate for typical commercial jobs.

2. Symptoms may include a lead line in the gums, a metallic taste in the mouth, constipation, vomitting, and nausea.

3. A severe upset stomach may be experienced. Symptoms may include: headache, chills, and tightness in the chest.

4. Poisoning from magenese and its alloys causes respiratory trouble and various changes in the welder's nervous system.

5. Cadimum plated or painted metals or metals covered with mercury give off deadly fumes when heated.

UNIT 2.0

WELDING MATH

WELDING
MATH
SUGGESTED INSTRUCTION TIME

Math UNIT/TASK		SUGGESTED HOURS
Unit 2.0		
2.01	Basic Welding Math - Fractions	6
2.02	Basic Welding Math - Decimals	6
2.03	Basic Welding Math - Volumes	1
2.04	Basic Welding Math - Areas	1
2.05	The Metric System	1

TASK LISTINGS
WELDING I

UNIT/TASK	DESCRIPTION
Unit 2.0	
2.01	(Basic Welding Math - Fractions) Given a pretest or examples by the instructor, conduct the following operations with fractions: (1) Change any fraction to a decimal number, and any terminating decimal number to a fraction. (2) Arrange in order...unit and simple nonunit fractions. (3) Write equivalent fractions in higher, lower, and lowest terms. (4) Write improper fractions as whole or mixed numbers, and mixed numbers as improper fractions. (5) Multiply fractions and mixed numbers, expressing answers in simplest form. (6) Divide fractions and mixed numbers, expressing answers in simplest form. (7) Add and subtract unlike fractions, expressing answers in simplest form. (8) Add and subtract mixed numbers with unlike fractions, expressing answers in simplest form. (9) Use rational numbers to solve simple work problems.
2.02	(Basic Welding Math - Decimals) Given a pretest or examples by the instructor, conduct the following decimal math operations: (1) Name the place value of digits in decimal numbers of up to nine digits before the decimal and six digits after the decimal. (2) Compare decimal numbers and arrange them in order. (3) Write the numeral for any decimal number of up to four decimal places. (4) Round decimal numbers to any designated place value up to thousandths. (5) Add and subtract decimal numbers of up to six digits. (6) Multiply decimal numbers by whole numbers or decimal numbers. (7) Divide a number by a three-digit decimal number. (8) Multiply and divide numbers by powers of ten, by inspection.
2.03	(Basic Welding Math - Volumes) Given a pretest or examples by the instructor, find the volume of any rectangular prism or cube.
2.04	(Basic Welding Math - Areas) Given a pretest or examples by the instructor, find the area of the following types of figures: (a) Rectangle, square, and parallelogram, (b) Triangle and trapezoid, (c) Circle, and (d) Surface area of any rectangular prism, cube, or cylinder.
2.05	(The Metric System) Given basic instruction in the metric system and conversion from United States Customary units to metric; read and convert specifications and dimensions from one system into the other system on teacher or text assigned problems with 100 percent accuracy.

UNIT 2.0 WELDING I

TASK 2.01 BASIC WELDING MATH - FRACTIONS

PERFORMANCE OBJECTIVE:

Given a pretest or examples by the instructor, conduct the following operations with fractions:

1. Change any fraction to a decimal number, and any terminating decimal number to a fraction.
2. Arrange in order...unit and simple nonunit fractions.
3. Write equivalent fractions in higher, lower, and lowest terms.
4. Write improper fractions as whole or mixed numbers, and mixed numbers as improper fractions.
5. Multiply fractions and mixed numbers, expressing answers in simplest form.
6. Divide fractions and mixed numbers, expressing answers in simplest form.
7. Add and subtract unlike fractions, expressing answers in simplest form.
8. Add and subtract mixed numbers with unlike fractions, expressing answers in simplest form.
9. Use rational numbers to solve simple word problems.

PERFORMANCE ACTIONS:

Consult: Curriculum Guide for High School General Mathematics, Greenville, SC: The School District of Greenville County, 1979.

PERFORMANCE STANDARDS:

- Student should be able to complete pretest in Math Curriculum Guide with 90 percent accuracy.
- Consult the Math Curriculum Guide for pretests, suggested exercises, and references.

NOTE: The level of this math skill is eighth grade, General Math I.

SUGGESTED INSTRUCTION TIME: 6 Hours (Actual hours of instruction will be determined by student's math skill as indicated by pretest. Remedial instruction may be at initiation of Welding I or as the actual skill is required.)

UNIT 2.0 WELDING I

TASK 2.02 BASIC WELDING MATH - DECIMALS

PERFORMANCE OBJECTIVE:

Given a pretest or examples by the instructor, conduct the following decimal math operations:

1. Name the place value of digits in decimal numbers of up to nine digits before the decimal and six digits after the decimal.
2. Compare decimal numbers and arrange them in order.
3. Write the numeral for any decimal number of up to four decimal places.
4. Round decimal numbers to any designated place value up to thousandths.
5. Add and subtract decimal numbers of up to six digits.
6. Multiply decimal numbers by whole numbers or decimal numbers.
7. Divide a number by a three-digit decimal number.
8. Multiply and divide decimal numbers by powers of ten, by inspection.

PERFORMANCE ACTIONS:

Consult: Curriculum Guide for High School General Mathematics, Greenville, SC: The School District of Greenville County, 1979.

PERFORMANCE STANDARDS:

- Student should be able to complete pretest in Math Curriculum Guide with 90 percent accuracy.
- Consult: Curriculum Guide for High School General Mathematics, 1979, for pretests, suggested exercises, and references.

SUGGESTED INSTRUCTION TIME: 6 Hours (Actual hours of instruction will be determined by the student's math skill as indicated by pretest. Remedial instruction may be at initiation of Welding I or as the actual skill is required.)

NOTE: The level of this math skill is eighth grade, General Math I.

UNIT 2.0 WELDING I

TASK 2.03 (OPTIONAL) BASIC WELDING MATH - VOLUMES

PERFORMANCE OBJECTIVE:

Given a pretest or examples by the instructor, find the volume of any rectangular prism or cube.

PERFORMANCE ACTIONS:

Consult: Curriculum Guide for High School General Mathematics, Greenville, SC: The School District of Greenville County, 1979.

PERFORMANCE STANDARDS:

- Student should be able to complete pretest in Math Curriculum Guide with 90 percent accuracy.
- Consult: Math Curriculum Guide for pretests, suggested exercises, and references.

SUGGESTED INSTRUCTION TIME: 1 Hour (Actual hours of instruction will be determined by the student's math skill as indicated by pretest. Remedial instruction may be at initiation of Welding I or as the actual skill is required.)

NOTE: The level of this math skill is eighth grade, General Math I.

UNIT 2.0 WELDING I

TASK 2.04 (OPTIONAL) BASIC WELDING MATH - AREAS

PERFORMANCE OBJECTIVE:

Given a pretest or examples by the instructor, find the area of the following types of figures:

a. Rectangle and square
b. Circle

PERFORMANCE ACTIONS:

Consult: Curriculum Guide for High School General Mathematics, Greenville, SC: The School District of Greenville County, 1979.

PERFORMANCE STANDARDS:

- Student should be able to complete pretest in Math Curriculum Guide with 90 percent accuracy.
- Consult the Math Curriculum Guide for pretests, suggested exercises, and references.

SUGGESTED INSTRUCTION TIME: 1 Hour (Actual hours of instruction will be determined by the student's math skill as indicated by pretest. Remedial instruction may be at initiation of Welding I or as the actual skill is required.)

NOTE: The level of this math skill is eighth grade, General Math I.

UNIT 2.0 WELDING I

TASK 2.05 (OPTIONAL) THE METRIC SYSTEM

PERFORMANCE OBJECTIVE:

Given basic instruction in the metric system and conversion from United States Customary units to metric; read and convert specifications and dimensions from one system into the other system on teacher or text assigned problems with 100 percent accuracy.

PERFORMANCE ACTIONS:

2.0501 Demonstrate ability to read and use U.S. Customary length measurements.

2.0502 Identify basic SI units and symbols.

Unit	Name	Symbol
Length	Meter	m
Electric Current	Ampere	A
Temperature	Kelvin	K

2.0503 Identify basic Metric prefixes:

Prefix	Amount	Fraction	Decimal
Milli	One-thousandth	1/1000	0.001
Centi	One-hundredth	1/100	0.01
Deci	One-tenth	1/10	0.1
Deka	Ten	10	10.0
Hecto	Hundred	100	100.0
Kilo	Thousand	1000	1000.0

2.0504 Convert Inches to Millimeters
Inches x 25.4 = Millimeters

2.0505 Convert Millimeters to Inches
Millimeters x 0.0394 = Inches

PERFORMANCE STANDARDS:

- Accuracy of 100 percent in conversion of length from one system to the other system.

UNIT 2.0 WELDING I

TASK 2.05 (OPTIONAL) THE METRIC SYSTEM (Con't.)

SUGGESTED INSTRUCTION TIME: 1 Hour

RELATED TECHNICAL INFORMATION:

- ANSI Standards
- System International d'United (SI) ((Metric System))
- U.S. Customary Measurements System

UNIT 3.0

MEASURING

WELDING I
OXYACETYLENE
SUGGESTED INSTRUCTION TIME

WELDING I UNIT/TASK		SUGGESTED HOURS
Unit 3.0		
3.01	Measuring in Welding	6

TASK LISTINGS
MEASURING
OXYACETYLENE

UNIT/TASK	DESCRIPTION
Unit 3.0	
3.01	(Measuring in Welding) Given proper instructions, read a rule and use other measuring tools with the precision necessary to take measurements from drawings, cut metal to exact lengths and angles, and set them up for the welds.

UNIT 3.0 MEASURING

TASK 3.01 MEASURING IN WELDING

PERFORMANCE OBJECTIVE:

Given proper instructions, read a rule and use other measuring tools with the precision necessary to take measurements from drawings, cut metal to exact lengths and angles, and set them up for the welds.

PERFORMANCE ACTIONS:

3.0101 Define measuring terms with 80 percent accuracy.

3.0102 Accurately identify basic tools used in measuring in welding.

3.0103 Read a rule to the nearest feet, inches, and fractions of inches down to 1/16 inch.

3.0104 Demonstrate ability to perform following measuring skills:

a. Measure objects to nearest sixteenth of an inch when given pictures of objects and a measuring instrument

b. Draw lines and objects to specified dimensions

PERFORMANCE STANDARDS:

- Demonstrate ability to measure to 1/16 inch and draw lines or objects to specified dimensions (1/16 inch accuracy).

SUGGESTED INSTRUCTION TIME: 6 Hours

RELATED TECHNICAL INFORMATION:

- Graduations on rule: Halves, quarters, eighths, sixteenths.
- Rules: Tapes (steel or other), folding rule, straight rule, steel square.

DEFINITIONS

MEASURING - Setting of limits or bounds according to a pre-determined standard.

INCH - Smallest whole unit of lineal measure typically used.

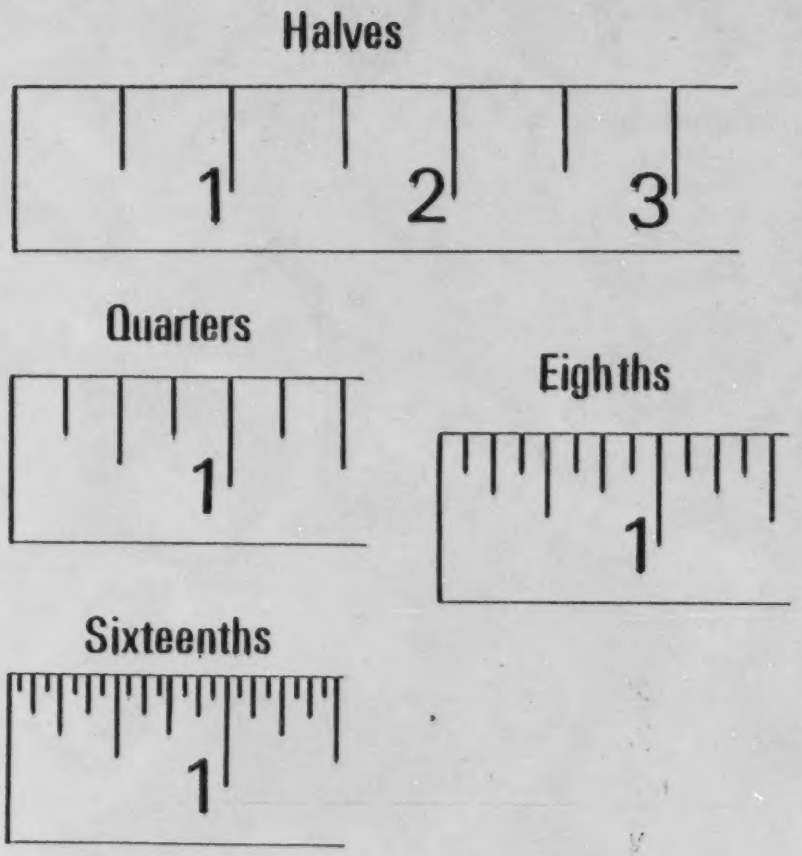
FOOT - Unit of measure consisting of twelve equal parts called inches.

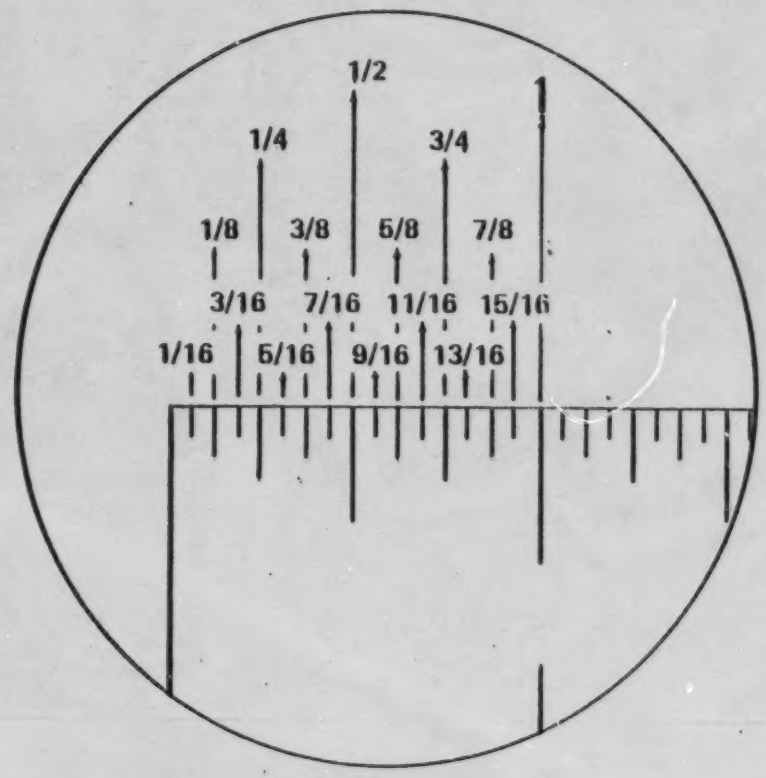
FRACTION - One or more equal parts of a whole. (i.e., 1/2 inch, 1/4 inch, 3/8 inch, 5/16 inch)

RULE - Instrument graduated in whole units and fractions of units and used in measuring.

DIMENSION - Number of full units and fraction of units between two points.

Graduations on a Rule

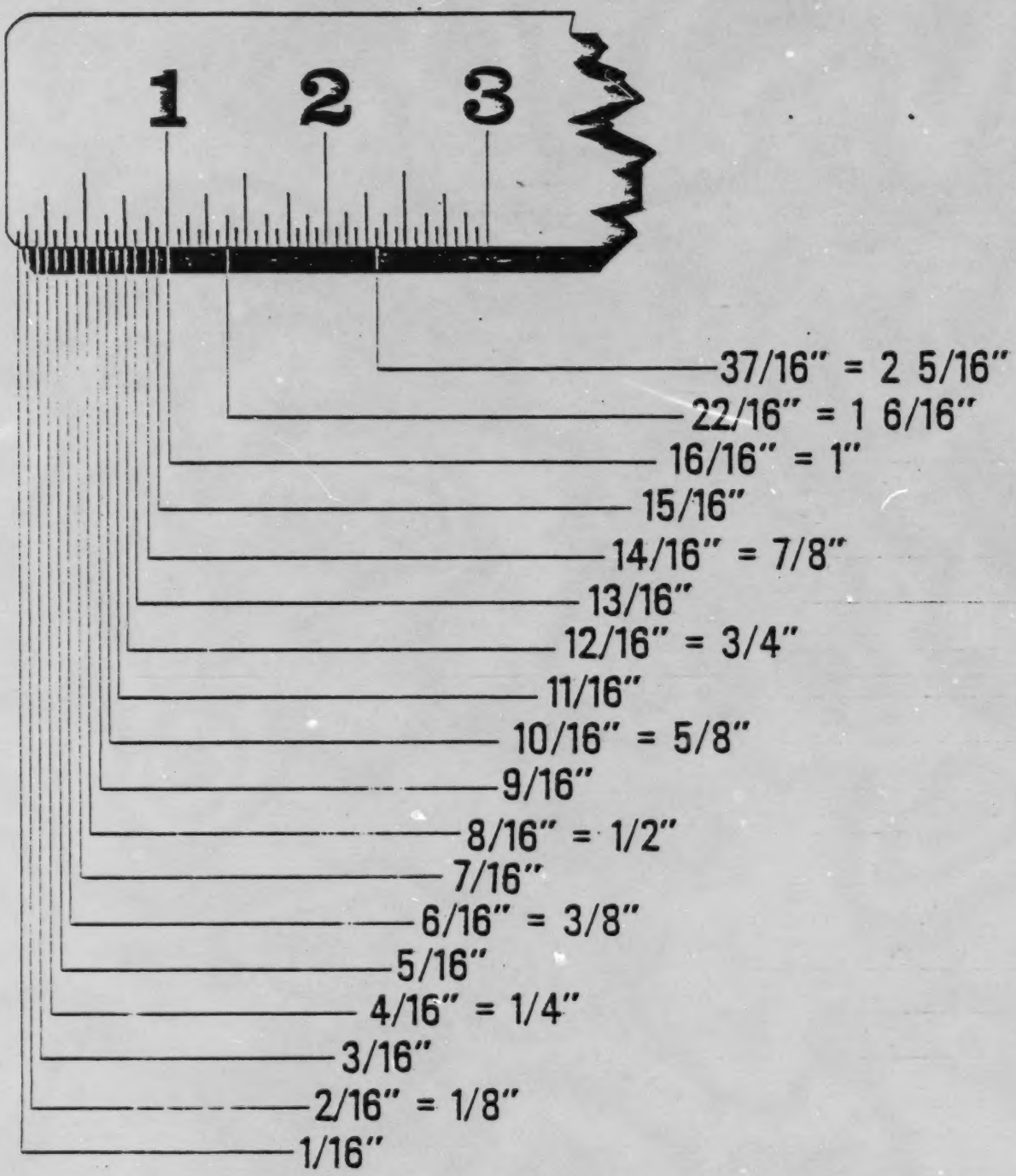




Graduations Applied to a Rule

Source: Cowan, Earl. Welding, Stillwater, OK: Oklahoma State Board of Vocational and Technical Education, 1974.

Reading the Sixteenths Rule



Source: Cowan, Earl. Welding, Stillwater, OK: Oklahoma State Board of Vocational and Technical Education, 1974.

UNIT 4.0

OXYACETYLENE CUTTING/WELDING (OAW)

OXYACETYLENE WELDING, CUTTING, AND BRAZING

PREREQUISITES: None

OBJECTIVES: The objective of oxyacetylene welding, cutting, and brazing (OAW) is to develop entry level skills for the following classifications of welders.

Welder, Gas (DOT 811.684-014)
Welder, Gas and Brazer Assembler portions of Combination Welder (DOT 819.384-010)
Brazer, Production Line and Gas Welders, Production Line (DOT 819.684-010)
Brazer, Assembler (DOT 813.684-010)
Thermal Cutter, Hand (DOT 816.464-010)

Oxyacetylene, welding, cutting, and brazing training develops the skills necessary to produce high quality single and multi-pass welds on mild steel plate and pipe in the flat, horizontal, vertical, and overhead positions. The welder is trained to produce high quality flame cutting through the use of manual and machine operated flame cutting equipment. Skill at producing high quality brazed joint on mild steel.

Upon completing secondary training, the student should be skilled to set up OAW equipment and perform the industrial requirements of OAW welding, cutting, and brazing.

Unit No. 4.0 Title: OXYACETYLENE CUTTING/WELDING

MODULE STANDARDS

(Standards that are in effect for the entire module and that are not optional. Standards applicable only to a particular set of tasks or functions will be described on the Performance Standards page.)

1. Select tip.

   a. Proper size for work to be done (thickness of metal).

2. Inspect tip for signs of damage or flaws that could create a hazard or impair performance.

   a. Seat area: Smooth and clean to ensure good metal seal with torch head.
   b. Cutting oxygen orifice: Free of slag or spatter or other obstruction that may deform oxygen stream and render a poor quality cut.
   c. Pre-heat flame orifices: Free of obstruction. (Clogged or obstructed orifices will extend required pre-heat time and result in poor performance and cutting efficiency.
   d. O-Rings: Check for deterioation.

3. Install tip.

4. Set gas pressures for desired working pressure.

WELDING I
OXYACETYLENE
SUGGESTED INSTRUCTION TIME

WELDING I UNIT/TASK		SUGGESTED HOURS
Unit 4.0		
4.01	Oxyacetylene Cutting/Welding Terminology	N/A
4.02	Oxyacetylene Cutting/Welding Safety	20
4.03	Perform Soap and Water Test (Safety)	***
4.04	Identifying Oxygen and Acetylene Gases and Cylinder Handling	4-6
4.05	Set Up Oxyacetylene Cutting/Welding Station	3
4.06	Clean Oxyacetylene Cutting/Welding Tips	1-2
4.07	Lighting the Torch	9-15
4.08	Adjusting Flame	**
4.09	Oxyacetylene Cutting	**
4.10	Preparing the Joint	3
4.11	Carrying the Puddle (Fuse)	4-6
4.12	Run a Bead With Filler Rod	6
4.13	Weld Open Butt Joint, All Positions*	45
4.14	Weld T-Joint, All Positions*	20
4.15	Fillet Weld, Lap Joint, Flat and Overhead Positions*	4
4.16	Weld Corner Joint (Outside) Flat Position	2
4.17	Construct Pipe Weld in Fixed Positions*	*
4.18	Braze Mild Steel	*

*Optional
**See Task 4.07
***Orientation Task

TASK LISTINGS
WELDING I
OXYACETYLENE

UNIT/TASK	DESCRIPTION
Unit 4.0	
4.01	(Oxyacetylene Cutting/Welding Terminology) Given proper instructions, identify standard oxyacetylene cutting/welding terms, typically used in daily operations, on a written test with 80 percent accuracy. Use standard oxyacetylene cutting/welding terminology upon completion of the training module to the standards of the instructor.
	Terms and definitions adapted from: Welding, Cutting & Heating Guide, Denton, TX: Victor Equipment Co., pp. 54-57, 1977.
4.02	(Oxyacetylene Cutting/Welding Safety) Given proper instructions concerning oxyacetylene cutting/welding safety; demonstrate proper use of protective clothing and equipment to protect against hazards in gas cutting/welding with 100 percent accuracy.
4.03	(Perform Soap and Water Test [Safety]) Given oxyacetylene cutting/welding equipment to be tested for leaks, neutral soap and water, and proper instruction: perform a soap and water leak test. Mark (with tape, etc.) all discovered leaks for repair. Hoses and torch will not leak after repair and test.
4.04	(Identifying Oxygen and Acetylene Gases and Cylinder Handling) Given proper instructions and demonstration, identify with 100 percent accuracy characteristics of oxygen and acetylene gases and demonstrate proper handling of cylinders to the standards of the instructor.
4.05	(Set Up Oxyacetylene Cutting/Welding Station) Given oxyacetylene torch, regulators, hoses, check valves, cylinder wrench, oxygen, and fuel cylinders and portable cart; set up a portable or stationary oxyacetylene cutting/welding station. The oxy-fuel equipment will not leak and will operate safely as the manufacturer intended.
4.06	(Clean Oxyacetylene Cutting/Welding Tips) Given oxyacetylene cutting/welding equipment, tip cleaners, and instructions; clean both cutting/welding tips.
	(NOTE: This objective will become standard practice when using oxyacetylene welding and cutting equipment.)
4.07	(Lighting The Torch) Given oxyacetylene cutting/welding equipment, striker, sample metal to be used in job; light torch (for cutting).

(NOTE: Tasks of (a) lighting the torch and (b) adjusting the flame typically will be accomplished as a continuing action.)

4.08 (Adjusting Flame) Given oxyacetylene cutting/welding equipment including striker, adjust flame for job.

(NOTE: Tasks of (a) lighting torch and (b) adjusting flame typically will be accomplished as a continuous action.)

4.09 (Oxyacetylene Cutting) Given oxyacetylene cutting equipment, set up the equipment for a cutting job, and cut given thin and thick steel according to instructor's assignment.

4.10 (Preparing the Joint) Given metal to clean and prepare for welding or a welding job, select the best joint and prepare the joint for welding.

4.11 (Carrying the Puddle [Fuse]) Given oxyacetylene welding equipment and metal to weld without filler rod, establish a molten puddle and run straight even beads (without filler) in the flat or other positions assigned by the instructor.

4.12 (Run a Bead With Filler Rod) Given oxyacetylene welding equipment, steel plate, and filler rod; demonstrate the proper procedure for carrying the puddle with filler metal in the flat position or other positions that may be required by the instructor, to the instructor's standards.

4.13 (Weld Open Butt Joint, All Positions*) Given oxyacetylene welding station, filler rod, mild steel plates, personal safety equipment, and necessary tools and materials; groove weld a butt joint in all positions. The bead should be formed properly, straight, and uniform in ripple and width, with even height.

4.14 (Weld T-Joint, All Positions*) Given an oxyacetylene welding station, mild steel plates, and rod; construct a T-joint weld in all positions. Weld will be consistent in uniformity, penetration, and appearance and will bend 90 degrees without fracture or breaks.

4.15 (Fillet Weld, Lap Joint, Flat and Overhead* Positions) Given oxy-fuel work station, mild steel plate, rods; construct a lap weld in all positions. The weld will be straight, have consistency of width and height with proper build up and no slag, and will bend 180 degrees without cracks or breaks.

4.16 (Weld Corner Joint [Outside] Flat Position) Given an oxyacetylene welding station, mild steel plates, filler rods, personal safety equipment, and the necessary tools and materials; construct a corner joint in the Flat positions. The bead must be straight and uniform in height and width, have a uniform

ripple formation, have no undercut, porosity, craters, or oxidation, and must be fused with the base metal. The crater must be completely filled at the end of the joint.

4.17 (Construct Pipe Weld in Fixed Position*) Given an oxyacetylene welding station, mild steel pipes, filler rods, personal safety equipment, and the necessary tools and materials; weld given pipe in fixed positions. Bead must be straight and uniform in height and width, have a uniform ripple formation, have no undercut, porosity, craters, or oxidation, and be smooth on inside of pipe. Root bead must completely penetrate into root of joint.

4.18 (Braze Mild Steel) Given an oxyacetylene welding station, mild steel coupon, brazing rod, flux, personal safety equipment, and the necessary tools and materials; braze mild steel. Bead must be straight and uniform in height and width, have a uniform ripple formation and have no undercut, porosity, craters, or oxidation.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.01 OXYACETYLENE CUTTING/WELDING TERMINOLOGY

PERFORMANCE OBJECTIVE:

Given proper instructions, identify standard oxyacetylene cutting/welding terms, typically used in daily operations, on a written test with 80 percent accuracy. Use standard oxyacetylene cutting/welding terminology upon completion of the training module to the standards of the instructor.

PERFORMANCE STANDARDS:

- Eighty percent accuracy in identifying standard terminology typically used in oxyacetylene cutting/welding jobs.
- Upon completion of Module 4.0, use terminology to instructor's standards.

Terms and definitions adapted from: Welding, Cutting & Heating Guide, Denton, TX: Victor Equipment Co., pp. 54-57, 1977.

DEFINITIONS

ACETYLENE - Gas composed of two parts of carbon and two parts of hydrogen. When burned in an atmosphere of oxygen, it produces one of the highest flame temperatures obtainable.

ACETYLENE CYLINDER - Specially built container manufactured according to D.O.T. standards. Used to store and ship acetylene. (Occasionally called "tank" or "bottle.")

ACETYLENE REGULATOR - An automatic valve used to reduce acetylene cylinder pressures to torch pressures and to keep the pressures constant.

BEAD - Denotes the appearance of the finished weld; describes the neatness of the ripples formed by the metal while it was in an semiliquid state.

BEVEL - Angling the metal edge where welding is to take place.

BOND - Junction of the weld metal and the base metal.

BUILDUP - Amount a weld face is extended above the surface of the metals being joined.

DEFINITIONS CON'T.

BUTT JOINT - An assembly in which the two pieces joined are in the same plane, with the edge of one piece touching the edge of the other.

CARBURIZING - A carburizing flame is an oxygen-fuel gas flame with a slight excess of the fuel gas.

CONE - Inner visible flame shape of a neutral or near neutral flame.

CONTINUOUS WELD - Making the complete weld in one operation.

CORNER JOINT - Junction formed by edges of two pieces of metal touching each other at angle 90 degrees.

CRACKING - Action of opening a valve slightly and then closing the valve immediately.

CUTTING FLAME - Cutting by a rapid oxidation process at a high temperature. It is produced by a gas flame accompanied by a jet action which blows the oxides away from the cut.

CYLINDER - A container used to hold gases used in welding. See (Oxygen, Acetylene.)

EDGE JOINT - Joint formed when two pieces of metal are lapped with at least one edge of each at an edge of the other.

FILLER ROD - Metal wire that is melted and added to the welding puddle to produce the necessary increase in bead thickness. (See Welding Rod.)

FILLET - Weld metal in the internal vertex, or corner, of the angle formed by two pieces of metal, given the joint additional strength to withstand unusual stresses.

FILLET WELD - Metal fused into a corner formed by two pieces of metal whose welded surfaces are approximately 90 degrees to each other.

FLAME CUTTING - Cutting performed by an oxygen-fuel gas torch which has an oxygen jet.

FLAT POSITION - A horizontal weld on the upper side of a horizontal surface.

FUSION - Intimate mixing of molten metals.

DEFINITIONS CON'T.

HORIZONTAL POSITION - A weld performed on a horizontal seam at least partially on a vertical surface.

HOSE - Flexible medium used to carry gases from regulator to the torch. It is made of fabric and rubber.

JOINT - Where two pieces meet when a structure is made of smaller pieces.

LAP JOINT - A joint in which the edges of the two metals to be joined overlap one another.

LENS - A specially treated glass through which a welder may look at an intense flame without being injured by the harmful rays, or glare, radiating from this flame.

NEUTRAL FLAME - Flame which results from combustion of perfect proportions of oxygen and the welding gas. Used for most welding jobs.

ORIFICE - Opening through which gases flow. It is usually the final opening; or any opening controlled by a valve.

OUTSIDE CORNER WELD - Fusing two pieces of metal together, with the fusion taking place on the underpart of the seam.

OXIDIZING - Combining oxygen with any other substance. For example, a metal is oxidized when the metal is burned, i.e., oxygen is combined with all the metal or parts of it.

OXIDIZING FLAME - Flame produced by an excess of oxygen in the torch mixture, leaving some free oxygen which tends to burn the molten metal.

OXYGEN - A gas formed of the element oxygen. When it very actively supports combustion it is called burning; when it slowly combines with a substance it is called oxidation.

OXYGEN-ACETYLENE CUTTING - Cutting metal using the oxygen jet which is added to an oxygen-acetylene preheating flame.

OXYGEN-ACETYLENE WELDING - A method of welding which uses a fuel combination of two gases - oxygen and acetylene.

DEFINITIONS CON'T.

OXYGEN CYLINDER - A specially built container manufactured according to D.O.T. standards and used to store and ship oxygen.

OXYGEN REGULATOR - An automatic valve used to reduce cylinder pressures to torch pressures and to keep the pressures constant. They are never to be used as acetylene regulators.

PASS - Weld metal created by one progression along the weld.

PENETRATION - Depth of fusion into the base metal as measured from the surface of the base metal.

PREHEATING - Temperature to which a metal is heated before an operation is performed on the metal (welding, cutting, forming, etc.).

PUDDLE - Portion of a weld that is molten at the place the heat is supplied.

ROOT of WELD - That part of a weld farthest from the application of weld heat and/or filler metal side.

SLAG INCLUSIONS - Non-fused, non metallic substances in the weld metal.

TACK WELD - Small weld used to temporarily hold together components of an assembly.

T-JOINT - Joint formed by placing one metal against another at an angle of 90 degrees. The edge of one metal contacts the surface of the other metal.

TIP - Part of the torch at the end where the gas burns, producing the high-temperature flame. In resistance welding, the electrode ends are sometimes called tips.

TOE of WELD - Junction of the face of the weld and the base metal.

TORCH - The mechanism which the operator holds during gas welding and cutting, at the end of which the gases are burned to perform the various gas welding and cutting operations.

WELDING - Art of fastening metals together by means of interfusing the metals.

WELDMENT - Assembly of component parts joined together by welding.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.02 OXYACETYLENE CUTTING/WELDING SAFETY

PERFORMANCE OBJECTIVE:

Given proper instructions concerning oxyacetylene cutting/welding safety; demonstrate proper use of protective clothing and equipment to protect against hazards in gas cutting/welding with 100 percent accuracy.

PERFORMANCE ACTIONS:

4.0201 Identify different types and uses of body protection clothing and devices used in gas cutting/welding with 100 percent accuracy.

a. Goggles: One-piece and two-piece to filter light rays and protect eyes from hot metal and sparks.
b. Welding gloves.
c. Protective clothing:
   (1) Welding jackets or aprons, etc., as appropriate.
   (2) Recommendation not to wear trousers with cuffs.
   (3) Boots or leggings. (Recommendation not to wear canvas/cloth shoes.)

4.0202 Check oxyacetylene cutting/welding equipment for safe operation.

a. Test all hose and regulator connections with soap solution *(orientation task).
b. Never use oil or grease near oxygen and other fittings.
c. Identify oxygen and fuel cylinders without error.
d. Verify that cylinders are fastened in position correctly.
e. Inspect hoses, regulators for wear.
f. Check storage of empty and full cylinders for proper separation, position of cylinders, etc.

*See Task 4.0, "Perform Soap and Water Test"

Check oxyacetylene cutting/welding work area for proper ventilation. Should meet OSHA Standards.

4.0203 Demonstrate Safe Practices:

a. Use caution in picking up pieces of hot metal. Use pliers or tongs. Mark "hot" metal left to cool.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.02 OXYACETYLENE CUTTING/WELDING SAFETY (Con't.)

PERFORMANCE ACTIONS (Con't.):

b. Keep combustibles from heat.
c. Protect others from heat and hot slag.
d. Don't weld a completely closed container (Danger of expansion explosion).
e. Avoid wearing contact lenses when in welding area.

PERFORMANCE STANDARDS:

- Identify proper safety in oxyacetylene cutting/welding on a written knowledge test with 100 percent accuracy.
- Demonstrate use of protective equipment used in cutting/welding.
- Demonstrate safe practices in welding.
- Practice proper ventilation techniques in cutting/welding.

SUGGESTED INSTRUCTION TIME: 20 Hours

RELATED TECHNICAL INFORMATION:

- Identification of welding equipment.
- Orientation to dangers of oxyacetylene cutting/welding fumes or flash to welders (i.e., wearing of plastic contact lenses, burns, etc.).

NOTE: See "Safety Precautions for Oxygen and Acetylene," South Carolina Curriculum Guide for Welding, Columbia, SC: SC State Department of Education (Office of Vocational Education), 1972.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.03 PERFORM SOAP AND WATER TEST (SAFETY)

PERFORMANCE OBJECTIVE:

Given oxyacetylene cutting/welding equipment to be tested for leaks, neutral soap and water, and proper instruction; perform a soap and water leak test. Mark (with tape, etc.) all discovered leaks for repair. Hoses and torch will not leak after repair and test.

PERFORMANCE ACTIONS:

4.0301 Close torch valves.

4.0302 Apply normal pressure.

4.0303 Mix neutral soap and water.

4.0304 Brush soapy water over hoses and valves.

4.0305 Check for bubbles.

4.0306 Mark discovered leaks with tape.

4.0307 Relieve hose pressure.

4.0308 Repair hoses and torch as required.

4.0309 Recheck for leaks.

PERFORMANCE STANDARDS:

- Perform soap and water leak test on oxyacetylene cutting/welding equipment to instructor's standards.

SUGGESTED INSTRUCTION TIME: Orientation Task

RELATED TECHNICAL INFORMATION:

- Oxy-fuel cutting/welding equipment.
- Proper safety precautions.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.04 IDENTIFYING OXYGEN AND ACETYLENE GASES AND CYLINDER HANDLING

PERFORMANCE OBJECTIVE:

Given proper instructions and demonstration, identify with 100 percent accuracy characteristics of oxygen and acetylene gases and demonstrate proper handling of cylinders to the standards of the instructor.

PERFORMANCE ACTIONS:

4.0401
a. Identify with 100 percent accuracy characteristics of oxygen and acetylene gases.
b. Describe potential dangers in handling both gases and typical pressures under which gases should be used.

4.0402 Identify difference between oxygen and acetylene cylinders with 100 percent accuracy.

4.0403 Demonstrate proper handling of gas cylinders:
a. Fasten cylinders securely in upright position.
b. Use proper method (or tool) to open/close cylinder valves.
c. Demonstrate proper storage of cylinders.
d. Demonstrate proper handling of cylinders in training.

PERFORMANCE STANDARDS:

- Identify major characteristics of oxygen and acetylene gases that apply to welding on a written knowledge test with 100 percent accuracy.
- Demonstrate proper handling of gas cylinders to the standards of the instructor.

SUGGESTED INSTRUCTION TIME: 4-6 Hours

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.05 SET UP OXYACETYLENE CUTTING/WELDING STATION

PERFORMANCE OBJECTIVE:

Given oxyacetylene torch, regulators, hoses, check valves, cylinder wrench, oxygen, and fuel cylinders and portable cart; set up a portable or stationary oxyacetylene cutting/welding station. The oxy-fuel equipment will not leak and will operate safely as the manufacturer intended.

PERFORMANCE ACTIONS:

4.0501 Chain cylinders to cart.

4.0502 Remove cylinder cap.

4.0503 Crack cylinder valves to clean out foreign particles and inspect threads.

4.0504 Attach regulators.

4.0505 Install check valves.

4.0506 Attach hoses.

4.0507 Attach hoses to torch. (Set proper pressure for tips being used.)

4.0508 Check for leaks.

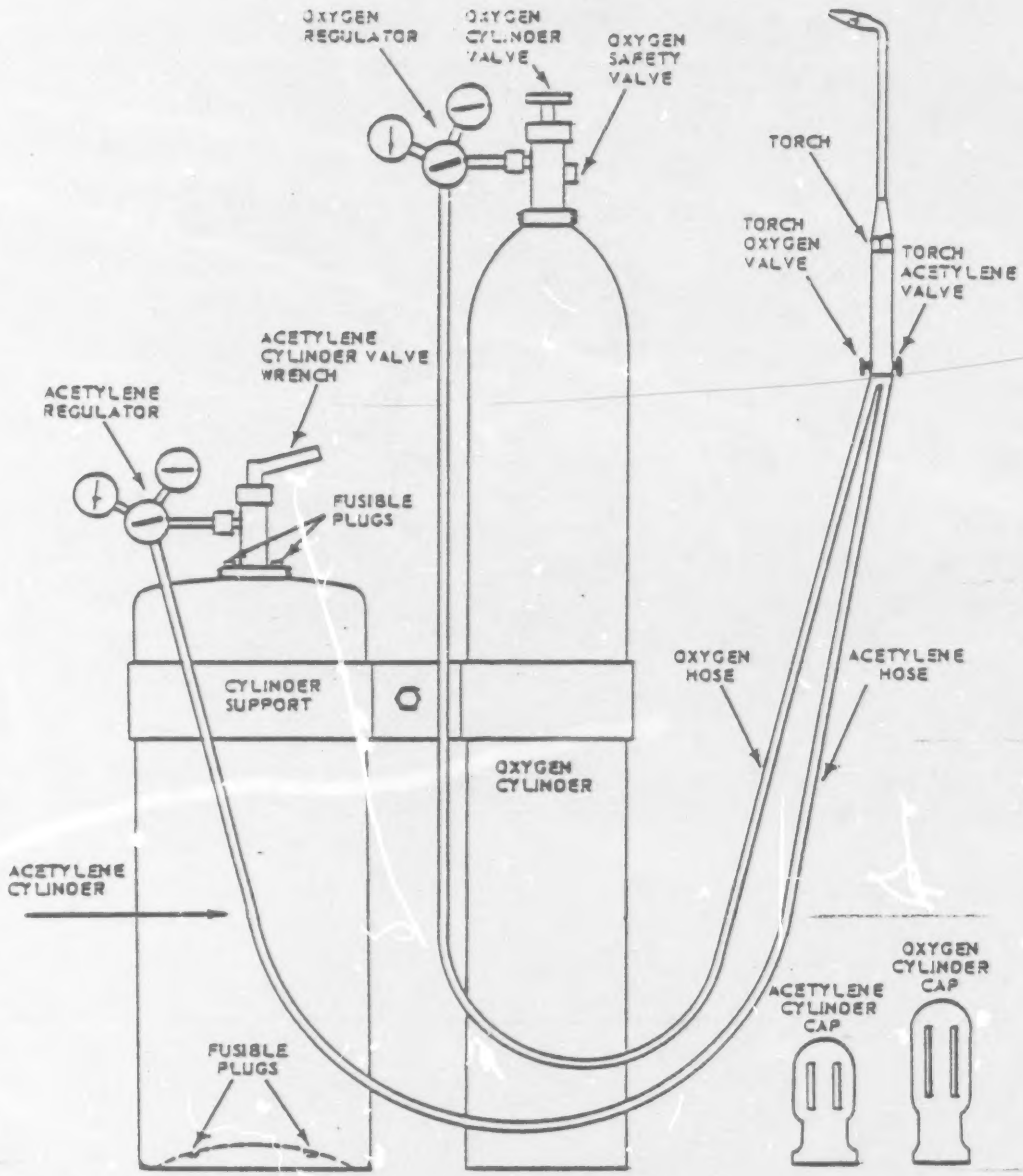
PERFORMANCE STANDARDS:

- Oxy-fuel equipment will not leak and will operate safely as the manufacturer intended.
- 90 percent minimum on knowledge test concerning cylinder handling, regulators, and set-up of oxy-fuel welding equipment.
- Set up oxyacetylene cutting/welding station to instructor's standards.

SUGGESTED INSTRUCTION TIME: 3 Hours

RELATED TECHNICAL INFORMATION:

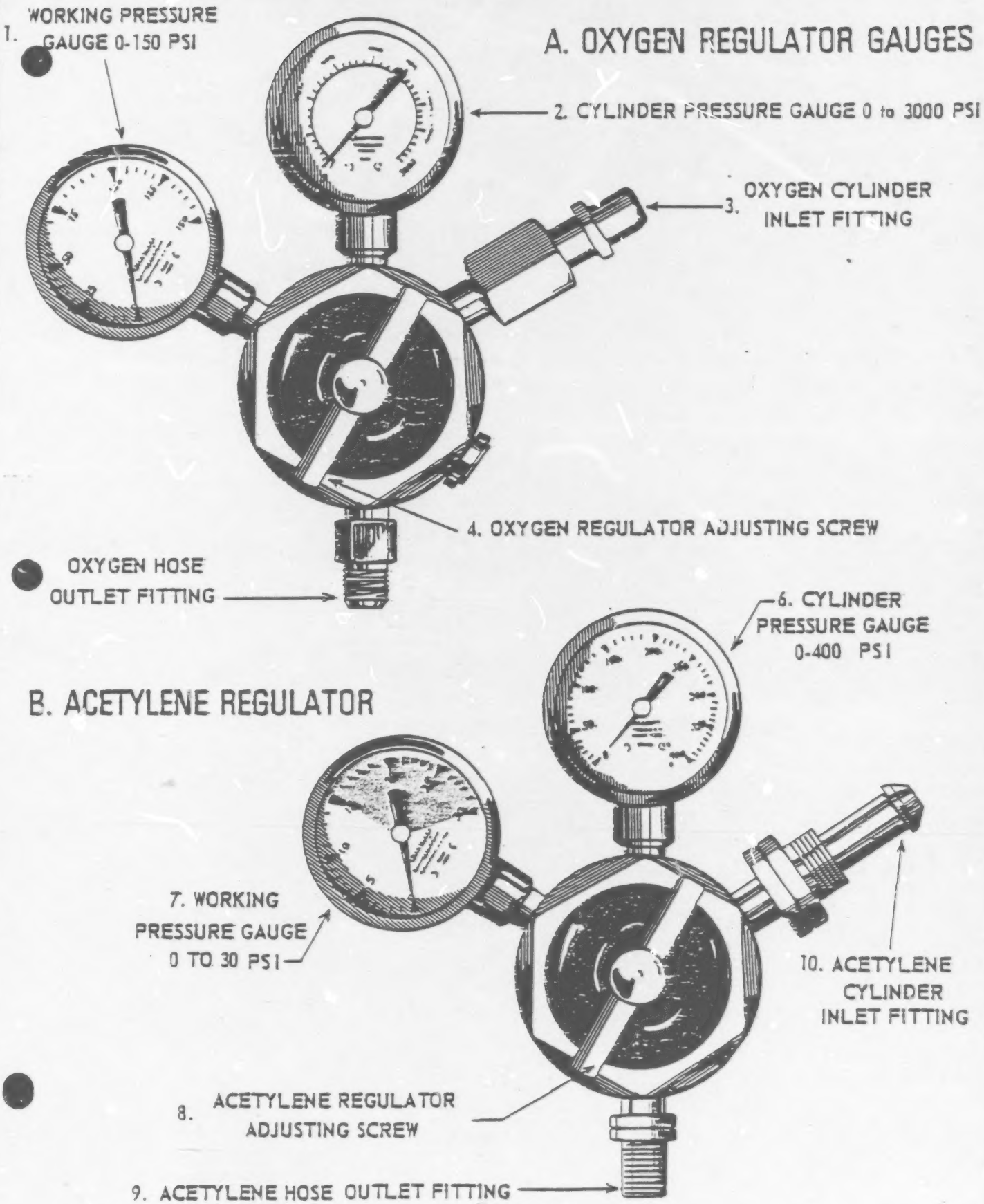
- Safety: a. Cylinder storage and handling
  b. Purging equipment
  c. Gas: (1) Pressures, (2) Ventilation
  d. Inspection procedures
- Manufacturer's specifications and instructions.



An oxygen-acetylene welding outfit.

Modern Welding, p. 53.

Welding Regulators


1. WORKING PRESSURE GAUGE 0-150 PSI
A. OXYGEN REGULATOR GAUGES
2. CYLINDER PRESSURE GAUGE 0 to 3000 PSI
3. OXYGEN CYLINDER INLET FITTING
4. OXYGEN REGULATOR ADJUSTING SCREW
OXYGEN HOSE OUTLET FITTING
6. CYLINDER PRESSURE GAUGE 0-400 PSI
B. ACETYLENE REGULATOR
7. WORKING PRESSURE GAUGE 0 TO 30 PSI
10. ACETYLENE CYLINDER INLET FITTING
8. ACETYLENE REGULATOR ADJUSTING SCREW
9. ACETYLENE HOSE OUTLET FITTING

UNIT	4.0	WELDING I - OXYACETYLENE
TASK	4.06	CLEAN OXYACETYLENE CUTTING/WELDING TIPS

PERFORMANCE OBJECTIVE:

Given oxyacetylene cutting/welding equipment, tip cleaners, and instructions; clean both cutting/welding tips.

NOTE: This objective will become standard practice when using oxyacetylene welding and cutting equipment.

PERFORMANCE ACTIONS:

4.0601 Examine tip to determine orifice (opening) size, and condition of orifice end of tip.

4.0602 Select proper (correct size) tip cleaner(s).

4.0603 (May be optional or orientation only). Smooth flame end of tip if it is scratched or rough (file orifice end) or use tip reamer.

4.0604 Clean tip:

a. Start with tip cleaner two sizes smaller than tip orifice.
b. Use straight push-pull action to eliminate egg-shaped opening.
c. Gradually increase tip cleaner size to original orifice size.
d. Where possible, insert long tip cleaners through back of tip.

PERFORMANCE STANDARDS:

- Clean tips to instructor's standards or manufacturer's recommendations, avoiding damage to tip, and reporting any damaged tips to instructor.

SUGGESTED INSTRUCTION TIME: 1-2 Hours

RELATED TECHNICAL INFORMATION:

- Determine that tips are being used with torches from the same manufacturer.
- Identify various tips.
- Identify typical tip sizes (No standard numbering system).

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.07 LIGHTING THE TORCH

PERFORMANCE OBJECTIVE:

Given oxyacetylene cutting/welding equipment, striker, sample metal to be used in job; light torch (for cutting).

NOTE: Tasks of (a) lighting the torch and (b) adjusting the flame typically will be accomplished as a continuing action.

PERFORMANCE ACTIONS:

4.0701 Select proper tip size for job. (Determine by thickness of metal.)

4.0702 Set regulator pressure for job.

4.0703
a. Open oxygen valve on torch handle.
b. Adjust oxygen regulator to desired delivery range.

4.0704
a. Open fuel valve on torch handle (1/2 turn).
b. Adjust fuel regulator to required delivery range.

4.0705 Point torch head (flame direction) away from persons, cylinders, or flammable materials before lighting.

4.0706
a. Open torch fuel valve approximately 1/2 turn.
b. Ignite gas. Hold torch in one hand and the spark lighter in the other hand.

PERFORMANCE STANDARDS:

- Select proper tip for welding job; adjust regulators according to text or teacher's instructions or manufacturer's standards; use proper safety equipment; and light torch.
- (Task typically will be accomplished jointly with adjusting flame.)

SUGGESTED INSTRUCTION TIME: 9-15 Hours

RELATED TECHNICAL INFORMATION:

- Able to set up oxy-fuel cutting/welding station.
- Selection of cutting/welding tips.
- Wear protective goggles to shield against bright light.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.08 ADJUSTING FLAME

PERFORMANCE OBJECTIVE:

Given oxyacetylene cutting/welding equipment including striker, adjust flame for job.

NOTE: Tasks of (a) lighting torch and (b) adjusting flame typically will be accomplished as a continuous action.

PERFORMANCE ACTIONS:

4.0801 Light torch. (Point flame away from persons, cylinders, or any flammable materials.)

4.0802 a. Keeping opening fuel valve until flame stops smoking and leaves end of tip by about 1/8 inch.
b. Then, slightly reduce fuel supply to bring flame back to tip.

4.0803 Open torch oxygen needle adjustment valve until a bright neutral flame (for cutting) is reached.

PERFORMANCE STANDARDS:

- Adjust torch to a neutral flame (for cutting) to meet manufacturer's specifications, or instructor's standards.
- (Task may be accomplished jointly with lighting the torch.)

SUGGESTED INSTRUCTION TIME: N/A - See Note

RELATED TECHNICAL INFORMATION:

CAUTION: If backfire or flashback is experienced, immediately turn off oxygen valve, then turn off fuel valve.

- Oxidizing flame.
- Carburizing flame.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.09 OXYACETYLENE CUTTING

PERFORMANCE OBJECTIVE:

Given oxyacetylene cutting equipment, set up the equipment for a cutting job, and cut given thin and thick steel according to instructor's assignment.

PERFORMANCE ACTIONS:

4.0901 Make usual preparations for cutting.

4.0902
a. Set oxygen regulator.
b. Set acetylene regulator.
c. Adjust as necessary.

4.0903
a. Turn on acetylene valve.
b. Light torch with sparklighter (striker). (NOTE: Avoid using butane lighters and matches!)

4.0904
a. Turn on oxygen preheating valve.
b. Adjust to neutral flame.

4.0905 Press oxygen high-pressure lever and observe preheating flame.

4.0906 Position steel plate.

4.0907
a. Hold torch tip at right angle to plate with inner cones +/- 1/8 inch above plate.
b. Heat edge of plate to bright red (at guideline).
c. Press oxygen cutting level and move torch forward along guidelines to begin cut.

4.0908 Move torch fast enough to maintain smooth, even cut on thin and thick steel. (If cutting actions stops, release oxygen cutting lever and preheat at end of kerf and continue cut when steel becomes red.)

PERFORMANCE STANDARDS:

- Set up complete oxyacetylene cutting station following proper sequence and safety precautions.
- Light and properly adjust flame for cutting job.
- Cuts must meet the instructor's standards and industry standards.
  NOTE: Proper cutting speed can be mastered only through experience.

UNIT	4.0	WELDING I - OXYACETYLENE
TASK	4.09	OXYACETYLENE CUTTING (Con't.)

SUGGESTED INSTRUCTION TIME: (Combined with 4.07 and 4.08)

RELATED TECHNICAL INFORMATION:

- Oxyacetylene safety: Equipment, operation, personal.
- Cut lines outlined by soapstone or chalk.

RECOMMENDED:

- Use only enough flame to cut metal.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.10 PREPARING THE JOINT

PERFORMANCE OBJECTIVE:

Given metal to clean and prepare for welding or a welding job, select the best joint and prepare the joint for welding.

PERFORMANCE ACTIONS:

4.1001 Select type of joint: (Select simplest joint to produce strongest weld possible.)
- a. Lap
- b. Butt
- c. Edge
- d. Corner
- e. T

4.1002 Prepare joint:
- a. Prepare metal for deep penetration, keeping metal edges true and straight.
- b. Clean and dry metal prior to welding.

PERFORMANCE STANDARDS:

- The best (simplest) joint to produce the strongest weld possible must be chosen as judged by the welding instructor and the joint must be properly prepared for welding, to include free from any material that might weaken the weld, and cuts that are appropriate for the weld to be made.

SUGGESTED INSTRUCTION TIME: 3 Hours

RELATED TECHNICAL INFORMATION:

- Oxyacetylene cutting.
- Metal characteristics (thickness and appropriate welding joints).

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.11 CARRYING THE PUDDLE (FUSE)

PERFORMANCE OBJECTIVE:

Given oxyacetylene welding equipment and metal to weld without filler rod, establish a molten puddle and run straight even beads (without filler) in the flat or other positions assigned by the instructor.

PERFORMANCE ACTIONS:

4.1101 Put on safety equipment.

4.1102 Position steel on support (table, etc) as instructed and to the standards of the instructor.

4.1103 Set up oxyacetylene welding station and adjust regulators.

4.1104 Light torch and adjust for a neutral flame.

4.1105 Point flame in direction of weld at 35-45 degree angle with no side angle.

4.1106 Lower torch until inner flame is about 1/8 inch from metal.

4.1107 (Recommend) Begin weld at right hand edge of metal. (If right handed.)

4.1108 Move flame in small circle until pool of molten metal forms (about 1/4 inch in diameter).

4.1109 Move flame along line of intended weld to form overlapping circles (carry the puddle) in uniform bead. (Scribe a line or use a straight edge to help puddle a straight bead.)

(NOTE: Practice will be required to develop skill in puddling.)

PERFORMANCE STANDARDS:

- Run a bead without filler rod, according to the instructor's standards, keeping the bead straight and maintaining a uniform puddle.

UNIT	4.0	WELDING I - OXYACETYLENE
TASK	4.11	CARRYING THE PUDDLE (FUSE) (Con't.)

SUGGESTED INSTRUCTION TIME: 4-6 Hours

RELATED TECHNICAL INFORMATION:

- Safety procedures.
- Setting up oxy-fuel station.
- Flame adjustment.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.12 RUN A BEAD WITH FILLER ROD

PERFORMANCE OBJECTIVE:

Given oxyacetylene welding equipment, steel plate, and filler rod, demonstrate the proper procedure for carrying the puddle with filler metal in the flat position or other positions that may be required by the instructor, to the instructor's standards.

PERFORMANCE ACTIONS:

4.1201 Put on safety equipment. Take safety precautions.

4.1202 Position metal.

4.1203 Set up oxy-fuel welding station.

4.1204 a. Establish puddle with torch angle 30-45 degrees.
b. Place inner cone about 1/16 inch from metal puddle.

4.1205 Begin travel when a molten puddle is established.

4.1206 Add filler rod to puddle, withdraw as necessary.

4.1207 Move puddle forward with torch, allowing puddle to form in base metal.

4.1208 Maintain puddle size and shape so that bead is smooth and in a straight line.

(NOTE: Practice will be required to develop consistently satisfactory results in running a bead.)

PERFORMANCE STANDARDS:

- Using oxyacetylene welding, run a bead with filler rod, in a straight line, with uniform width and height, with a weld penetrating about 100 percent thickness of metal base, consistently satisfactory to the instructor's standards.

SUGGESTED INSTRUCTION TIME: 6 Hours

RELATED TECHNICAL INFORMATION:

- Filler rod.
- Tip selection.
- Puddling.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.13 WELD OPEN BUTT JOINT, ALL POSITIONS

PERFORMANCE OBJECTIVE:

Given oxyacetylene welding station, filler rod, mild steel plates, personal safety equipment, and necessary tools and materials; groove weld a butt joint in all positions. The bead should be formed properly, straight, and uniform in ripple and width, with even height.

PERFORMANCE ACTIONS:

4.1301 Prepare for oxy-fuel welding.

4.1302 Position metal in butt joint, flat position.

4.1303 Tack weld each end of the joint to hold position.

4.1304 Run a bead, using acceptable standards (of industry), to weld a butt joint (all positions).

4.1305 Inspect weld for:
(a) Proper penetration (100 percent).
(b) Build up of weld around 1/16 inch above base surface.
(c) Bead straight and over center of joint.

PERFORMANCE STANDARDS:

- Weld a butt joint in all positions.
- The bead must be properly formed, straight, and uniform in ripple and width, with even height.
- There must be no undercut, porosity, craters, or oxidation, and the weld must be fused with the base metal.

SUGGESTED INSTRUCTION TIME: 45 Hours

RELATED TECHNICAL INFORMATION:

- Tip and rod selection.
- Preparing metal for weld.
- Testing of weld.
- Safety.

*ALL POSITIONS = Flat, Horizontal, Vertical, and Overhead.

UNIT 4.0 WELDING I - OXYACETYLENE

TASK 4.14 WELD T-JOINT, ALL POSITIONS*

PERFORMANCE OBJECTIVE:

Given an oxyacetylene welding station, mild steel plates, and rod; construct a T-joint weld in all positions. Weld will be consistent in uniformity, penetration, and appearance and will bend 90 degrees without fracture or breaks.

PERFORMANCE ACTIONS:

4.1401 Prepare for oxy-fuel welding.

4.1402 Position steel plates in T configuration.

4.1403 Tack weld each end of the joint.

4.1404 Inspect joint to ensure that plates are at right angles to each other after the tack weld. (Correct vertical plate with hammer if angle is not correct.)

4.1405 Direct torch 45 degrees to both plates and 60 degrees to horizontal plates. Start molten puddle, add filler rod, and run bead.

4.1406 Fillet weld T-joints according to industry standards. (NOTE: Watch for undercutting of vertical plate due to overheating.)

4.1407 Inspect weld for proper penetration, pocketing (bridging).

4.1408 Test weld.

PERFORMANCE STANDARDS:

- Fillet weld on T-joints in all positions.
- Joint must be correctly positioned.
- Weld must be uniform, consistent, with proper penetration, show uniform fusion, good surface ripple, and; meet industry standards.

SUGGESTED INSTRUCTION TIME: 20 Hours

UNIT	4.0	WELDING I - OXYACETYLENE
TASK	4.14	WELD T-JOINT, ALL POSITIONS* (Con't.)

RELATED TECHNICAL INFORMATION:

- Safety.
- Tip and rod selection.
- Positioning of T-Joint plates.
- Tack welding.
- Undercutting.
- Testing T-Joint weld.

*Primarily flat or vertical position is used for secondary training.

NOTE: Tasks 4.14 and 4.15 may be exchanged in sequence.

UNIT	4.0	WELDING I - OXYACETYLENE
TASK	4.15	FILLET WELD, LAP JOINT, FLAT* AND OVERHEAD POSITIONS

PERFORMANCE OBJECTIVE:

Given oxy-fuel work station, mild steel plate, rods; construct a lap weld in all positions. The weld will be straight, have consistency of width and height with proper build up and no slag, and will bend 180 degrees without cracks or breaks.

PERFORMANCE ACTIONS:

4.1501 Make necessary preparations for welding.

4.1502 Position steel plates for lap welding.

4.1503 Tack weld each of the plates.

4.1504 Start molten pool at end of joint, with or without filler rod and run bead to complete lap joint.

4.1505 Inspect weld for smoothness, even ripple, uniform and complete penetration.

SPECIAL NOTE: Practice in oxyacetylene lap joint welding typically will be limited to conserve practice steel.

PERFORMANCE STANDARDS:

- Weld lap joint of carbon steel plates with oxyacetylene equipment.
- The weld must be consistent and uniform, show uniform fusion, good surface ripple, and have no slag.
- The weld must bend 180 degrees without cracks or breaks.
- The finished weld must meet the instructor's standards.

SUGGESTED INSTRUCTION TIME: 4 Hours

RELATED TECHNICAL INFORMATION:

- Welding procedures to ensure proper heating of top and bottom plates.
- Safety.

*Secondary training may concentrate on flat position.

UNIT	4.0	WELDING I - OXYACETYLENE
TASK	4.16	WELD CORNER JOINT (OUTSIDE) FLAT POSITION

PERFORMANCE OBJECTIVE:

Given an oxyacetylene welding station, mild steel plates, filler rods, personal safety equipment, and the necessary tools and materials; construct a corner joint in the flat positions. The bead must be straight and uniform in height and width, have a uniform ripple formation, have no undercut, porosity, craters, or oxidation, and must be fused with the base metal. The crater must be completely filled at the end of the joint.

PERFORMANCE ACTIONS:

4.1601 Make necessary preparations for welding.

4.1602 Position steel plates at 90 degrees angle. Line up inner edges so they are even and touch.

4.1603 Tack weld each end of the joint to hold plates in position.

4.1604 Start molten pool at end of the joint and move puddle forward, forming bead by fusing equal amount of metal from each plate.

4.1605 Check weld for consistency, uniform bead, proper penetration, complete fusion, and good surface ripple.

PERFORMANCE STANDARDS:

- Weld outside corner (or edge) joint of carbon steel plates by gas welding flat position.
- Weld must be consistent and uniform, with proper penetration, complete fusion, and good surface ripple.
- Weld must withstand classroom test for quality and not show any cracking or incomplete fusion and must meet instructor's standards.

SUGGESTED INSTRUCTION TIME: 2 Hours

RELATED TECHNICAL INFORMATION:

- Puddling without filler.

UNIT	4.0	WELDING I - OXYACETYLENE
TASK	4.17 (OPTIONAL)	CONSTRUCT PIPE WELD IN FIXED POSITION*

PERFORMANCE OBJECTIVE:

Given an oxyacetylene welding station, mild steel pipes, filler rods, personal safety equipment and the necessary tools and materials; weld given pipe in fixed positions. Bead must be straight and uniform in height and width, have a uniform ripple formation, have no undercut, porosity, craters, or oxidation, and be smooth on inside of pipe. Root bead must penetrate completely into root of joint.

PERFORMANCE ACTIONS:

4.1701 Prepare for oxyacetylene welding.

4.1702 Prepare pipe nipples if applicable.

4.1703 Position pipe according to specifications.

4.1704 Tack weld pipe.

4.1705 Deposit root bead. (Penetrate joint and fill +/- 2/3 of joint.)

4.1706 Deposit second weld bead.

4.1707 Inspect finished weld; inspect inside of pipe if possible.

PERFORMANCE STANDARDS:

- Weld given mild steel pipe in specified position so that the finished weld is straight and uniform in height and width, has a uniform ripple formation, has no undercut, porosity, craters, or oxidation, and is smooth on inside of pipe.
- Root bead must penetrate completely into root of joint.

SUGGESTED INSTRUCTION TIME: Optional

RELATED TECHNICAL INFORMATION:

- *Positions may include: Flat: 5G
  Vertical: 2G
  Diagonal

UNIT	4.C	WELDING I - OXYACETYLENE
TASK	4.18 (OPTIONAL)	BRAZE MILD STEEL

PERFORMANCE OBJECTIVE:

Given an oxyacetylene welding station, mild steel coupon, brazing rod, flux, personal safety equipment, and the necessary tools and materials; braze mild steel. Bead must be straight and uniform in height and width, have a uniform ripple formation and have no undercut, porosity, craters, or oxidation.

PERFORMANCE ACTIONS:

4.1801 Set up oxyacetylene welding station for brazing.

4.1802 Position mild steel coupon to braze:
(a) (Position plated in butt joint, flat position.)

4.1803 Position and tack weld material.

4.1804 Braze weld butt joint using slightly oxidizing flame:
(a) Heat end of filler rod.
(b) Dip rod in flux allowing flux to cling to heated metal.
(c) Heat tack welded areas to dull red; apply filler metal.

4.1805 Inspect weld.

PERFORMANCE STANDARDS:

- Braze weld mild steel plates so that the finished weld is flat to slightly convex, gold in color and penetrates through the joint.

SUGGESTED INSTRUCTION TIME: Optional

CHECKLIST FOR WELD

CHECK IF WELD PASSES INDUSTRY STANDARDS
(omit if it does not)

	Flat				Hor-zontal				Verti-cal				Over-head				Pipe *				*
	Butt	T	Lap	Corner	Butt	T	Lap	Corner	Butt	T	Lap	Corner	Butt	T	Lap	Corner	Flat	Horizontal	Diagonal		Brazing
1. Even bead.																					
2. Even ripples in bead.																					
3. Bead uniform in width.																					
4. Proper height in bead (not excessive).																					
5. No holes in weld.																					
6. Weld not brittle.																					
7. No excessive metal under joint.																					
8. Proper penetration.																					
9. No weld cracks.																					
10. End crater filled.																					
11. No cold overlaps along joint seam.																					
12. Good fusion and penetration.																					

*Optional task at secondary level.

UNIT 4.0 - OXYACETYLENE

OUTCOME-REFERENCED TESTS

1. What test should be performed upon completion of changing Oxygen-Acetylene tanks.

___ a. an air test
b. a visual test
c. soap and water test
d. none of the above

2. On lighting the torch, how many turns should the valve be opened on an Acetylene tank?

___ a. five turns
b. one to one and half turns
c. full open
d. 1/2 to 3/4 turns

3. The inter cone of the neutral flame is said to be about

___ a. 6300°
b. 5900°
c. about 6000°
d. all the above

4. A reducing type flame is said to have a

___ a. excess oxygen
b. excess acetylene
c. both No. 1 and 2
d. none of the above

5. When cleaning an oxyacetylene tip what size reamer should be selected first.

___ a. the exact size
b. one size larger
c. one size smaller
d. none of the above

6. Which type of flame is said to be a cool flame?

___ a. oxidizing flame
b. neutral flame
c. carburizing flame
d. none of the above

UNIT 4.0 OXYACETYLENE (Con't.)

COMPLETION

7. What type of clothing is recommended for use in the welding shop? _____

8. _____ leather shoes are recommended for use in welding.

9. When chipping slag the welder must wear _____.

10. A _____ should be worn when using a side grinder.

11. _____ should not be worn in the welding shop.

12. Report any repairs to the _____ before attempting repairs.

13. Oxyacetylene gauges should _____ be oiled.

14. Always use a _____ wrench when opening and closing oxyacetylene tanks.

15. Oxyacetylene tanks should always be _____ when stored in the upright position.

16. Acetylene becomes very unstable when line pressure exceeds _____.

17. Acetylene becomes very unstable if not mixed with _____.

18. The size of the Oxyacetylene welding tip is determined by _____ metal to be welded.

19. Which oxyacetylene hose has the left hand threads? _____

20. Which oxyacetylene tank has a double acting valve? Acetylene or Oxygen.

TRUE-FALSE

21. ___ Hot metal should always be handled with pliers or tongs.

22. ___ All items on the welding table are not always considered hot.

23. ___ Butane cigarette lighters are not considered dangerous to the welder when welding.

24. ___ Oxyacetylene tanks must be chained when in use.

25. ___ Heavy oxidation type flames are the most desirable when welding.

UNIT 4.0 - OXYACETYLENE

OUTCOME-REFERENCED TESTS

TASK 4.11-A

1. Name the (5) five basic weld joints.

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____

2. Of the five welding joints named above, which is the strongest joint?

   _____

3. One factor that contributes to good joint geometry is

   ___ a. narrow beveled angle at joint
   b. both plates of equal thickness
   c. no appreciable root face
   d. consistent fit-up along the entire joint

4. Each layer of beads deposited on the base metal is called a

   ___ a. face
   b. pass
   c. run
   d. toe

5. A depression in the base metal made by the arc as the electrode comes in contact with the base metal is called a

   ___ a. groove
   b. blowhole
   c. crater
   d. ripple

6. A fillet weld is made on a

   ___ a. flat surface
   b. lap joint
   c. open butt
   d. grooved joint

7. Which of these joints least likely to withstand excessive impact or bending loads?

___ a. square butt joint
b. lap joint
c. double T joint
d. double U butt joint

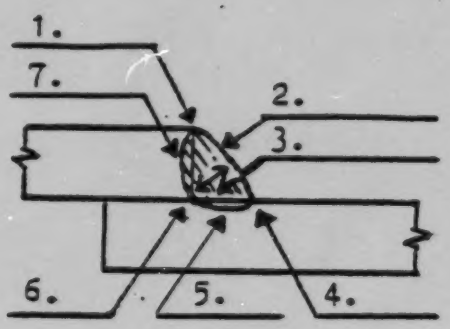
8. Which of these factors is not important in good joint design

___ a. sufficient gap
b. sufficient bevel
c. sufficient root opening
d. sufficient back-up strip

9. A deposit of one or more stringers or weave beads on an unbroken surface is called a _____ weld.

10. Identify each of the items below.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____



TASK 4.11-B

1. When you open an acetylene regulator, never open the valve:

___ a. more than five turns
b. less than five turns
c. more than one and one-half turns
d. at a high rate of speed

2. Oxy-acetylene welding is a type of:

___ a. blending
b. fusion
c. finishing
d. brazing

3. Lower the torch until the inner cone is about ____ of an inch from the metal.

___ a. 1/16"
b. 1/8"
c. 3/16"
d. 1/4"

4. When lighting a torch, point it in which direction:

___ a. left
b. right
c. up
d. down

5. Before connecting a regulator to a cylinder:

___ a. check to see whether there is any gas leakage
b. crack the cylinder valve to blow out dirt from the outlet nozzle
c. be sure the cylinder valves are closed tightly
d. wipe clean the cover glass over the gages

6. Always _____ cylinders to prevent them from tipping over.

TRUE-FALSE

7. ___ Acetylene hose connections have right-hand threads.

8. ___ The threads on the oxygen adjusting screw should occasionally be lubricated with light oil.

9. ___ When you test leaks, you should adjust the regulators-acetylene 20 lbs. oxygen 40 lbs.

UNIT 4.0 - OXYACETYLENE

OUTCOME-REFERENCED TESTS

TASK 4.12

1. Which of these statements is not true?

___ a. filler rod adds to the strength of a joint
b. filler rod should have the same properties as the base metal
c. a good filler rod will flow smoothly and blend easily with the base metal
d. a filler rod will spark profusely regardless of the kind of flame used

2. Which of these statements is true?

___ a. the diameter of a filler rod is usually not important in carrying out a weld
b. the rod to be used should normally be about the same diameter as the thickness of the base metal
c. for most welding jobs a 3/8" diameter rod should be used
d. the larger the rod diameter is, the greater the possibility of burn thru

3. Welding tip sizes are specified by:

___ a. manufacturer's trade name
b. a system of numbers which relate to the size of tip opening
c. their length
d. the type of welding to be done and amount of gas required

4. Which of the following should never be attempted?

___ a. using pliers to remove a tip
b. removing carbon from inside a tip with a tip cleaner
c. removing a tip only after the tip has cooled
d. occasionally brushing the end of the tip with fine sandpaper

5. A _____ flame causes the molten metal to boil, due to carbon entering the molten metal.

___ a. carbonizing
b. neutral
c. oxidizing
d. none of the above

TASK 4.12

6. The filler rod should be _____ in order to keep it away from the heat of the flame.

___ a. bent at right angle
b. held above the pool
c. inserted near the edge of the pool
d. of a large diameter

7. If the welding tip is too _____, holes will be burned in the metal.

8. Moving the torch too slowly or too rapidly causes _____ weld beads.

9. When the flame goes out with a loud pop, this is called a _____.

OUTCOME-REFERENCED TESTS

TASK 4.13

1. When gas welding light gage metal, some operators prefer to hold the torch:

___ a. like a pencil
b. near the tip
c. close to the needle valve
d. with both hands for a steady motion

2. To secure beads of uniform width and height you should:

___ a. keep the puddle from getting too fluid
b. move the torch slowly
c. flip the torch to one side if the puddle is getting too large
d. keep the torch moving forward at a uniform and steady speed

3. If the torch is moved forward too slowly:

___ a. penetration is likely to be inadequate
b. there will be excessive metal hanging under the joint
c. the weld is likely to be too brittle
d. the molten metal will lap over an area that is not melted

4. When welding the butt joint, the bead build up should be about:

___ a. 1/16"
b. 3/16"
c. 1/4"
d. 5/16"

5. Progressive spacing is sometimes used when plates are _____ welded, in order to allow for expansion.

6. Overhead welding requires very careful regulation of _____.

7. If a fillet rod is too large, the heat of the _____ will not be enough to melt it.

8. When the filler rod is not being applied, keep the tip inside the _____ of the flame.

9. What is a flashback? _____

TASK 4.13

10. Give a brief explanation of the following:

    a. fusion
    b. penetration
    c. weld reinforcement

11. Name at least (4) four causes of torch backfire.

    1. _____
    2. _____
    3. _____
    4. _____

TRUE-FALSE

12. ___ In making a gas weld, the filler rod should not touch the weld pool.

13. ___ The backhand welding is especially suited for light gauge sheet metal.

TASK 4.14

1. When welding vertical, point the torch upward in the direction of travel at about _____ degree angle.

   ___ a. 30
   b. 40
   c. 45
   d. 50

2. Oxy-acetylene welding in the vertical position, what should you do if the weld pool seems to be getting too hot?

   _____

3. Do tack welds have to be melted out, or can they become a part of the completed weld?

   _____

TRUE-FALSE

4. ___ When welding in the vertical position, slightly use a carburizing flame.

5. ___ When shutting off the gas welding torch, the oxygen needle valve should be closed down first.

UNIT 4.0 - OXYACETYLENE

OUTCOME-REFERENCED TESTS

TASK 4.15

1. A lap joint is made with a _____ weld.

   ___ a. surfacing
   b. groove
   c. plug
   d. fillet

2. Why is the lap joint the most difficult to weld?

   _____

TRUE-FALSE

3. ___ The weld face of a lap joint should be slightly convex.

4. ___ When welding a lap joint, one should tack all four corners.

5. ___ When welding the lap joint in the flat position, the bottom plate is the most sensitive to heat.

UNIT 4.0 - OXYACETYLENE

OUTCOME-REFERENCED TESTS

TASK 4.16

1. The corner or flange joints are used a great deal on sheet metal less than _____ gauge in thickness.

   ___ a. 5
   b. 10
   c. 16
   d. 24

2. When would one use a filler rod on a corner or flange joint?

   _____

3. Why should you protect the weld pool on the corner or flange joint?

   _____

TRUE-FALSE

4. ___ When tacking the corner or flange joint, you should tack the plates about every 2 inches.

5. ___ Penetration is not necessary when welding a corner or flange joint.

UNIT 4.0 - OXYACETYLENE

OUTCOME-REFERENCED TESTS

TASK 4.17

1. Before making a butt weld on pipe that is over _____ inch thick, bevel the ends of each pipe at an angle of 30 degrees to form a 60 degree included angle.

   ___ a. 3/16
   b. 1/8
   c. 1/4
   d. 1/2

2. How does one determine the amount of weld passes on pipe 3 inches and under in diameter?

   _____

TRUE-FALSE

3. ___ It is general practice to weld pipe with the oxyacetylene process.

4. ___ In tacking up a pipe joint, make sure that the pipe ends are not touching.

5. ___ Backhand welding is never used to weld pipe joints.

UNIT 4.0 - OXYACETYLENE

OUTCOME-REFERENCED TESTS

TASK 4.18

1. An important factor in joint design for brazing is:

___ a. adequate clamping provision
b. joint clearance
c. edge alignment
d. the type of flux used

2. Which of the following statement is not true?

___ a. clean, oxide-free surfaces are a must for good brazing
b. surface oxides can be removed by sanding, grinding, or wire brushing
c. surfaces for brazing should have somewhat of a rough texture
d. capillary action is not affected by joint spacing

3. When brazing with oxy-acetylene or Mapp-oxygen, use a thin metal:

___ a. slightly oxidizing flame
b. neutral flame
c. slightly reducing flame
d. single flame tip

4. The _____ mixture provides the lowest heat and is used mainly in brazing thin sections.

___ a. air-gas
b. gas-oxygen
c. mapp-oxygen
d. oxy-hydrogen

5. A _____ flux is the most commonly used for brazing.

___ a. gas
b. paste
c. liquid
d. powder

6. The _____ joint is the one most commonly used and the strongest of brazed joints.

___ a. butt
b. corner
c. lap
d. tee

TASK 4.18

7. In brazing, a _____ prevents or inhibits the formation oxide.

8. The bronze filler rod used in bronze welding is composed of _____ and tin zinc.

TRUE-FALSE

9. ___ Bronze welding is performed in the same way as fusion welding, except that the base metal is not melted.

10. ___ In bronze welding the flux is applied by dipping the heated rod into the flux and transferring it to the weld.

UNIT 4.0 - OXYACETYLENE

Answer sheet

1. c
2. d
3. b
4. b
5. c
6. c
7. 100% cotton
8. Ankle top steel hardtoe
9. safety glasses
10. face shield
11. Contact lense
12. instructor
13. never
14. tank
15. used
16. 15 PSI
17. acetone
18. thickness of
19. acetylene
20. oxygen
21. true
22. true
23. false
24. true
25. false

Task 4.11-A

1. 1. lap
   2. tee
   3. butt
   4. edge
   5. corner
2. butt
3. d
4. b
5. c
6. b
7. a
8. d
9. surface
10. 1. toe
    2. face
    3. throat
    4. toe
    5. leg
    6. root
    7. leg

Task 4.11-B

1. c
2. b
3. b
4. d
5. b
6. secure
7. false
8. false
9. false

Task 4.12

1. d
2. b
3. b
4. a
5. c
6. a
7. large
8. uneven
9. backfire

Task 4.13

1. a
2. d
3. b
4. a
5. butt
6.
7. torch
8.
9. a flashback occurs when the flame burns back inside the torch and causes a shrill hissing or squealing sound
10. a. Fusion is the complete blending of the two edges of the base metal being joined or the blending of the base metal and the filler metal.

    b. Penetration refers to the depth to which the base metal is melted and fused.

    c. A weld is said to be reinforced when the weld metal is build up above the surface of the metal being welded.
11. 1. Operating the torch at lower pressure than required for the tip size used.
    2. Touching the tip to the work.
    3. The tip may become overheated.
    4. A loose tip.
    5. The inside of the tip may have carbon deposits or small metal particles inside the holes.
    6. The seat of the tip may have dirt on it, and nicked through careless handling.
12. false
13. false

Task 4.14

1. c

2. raise the flame slightly so that it will not play directly upon the puddle and give it a chance to solidify.

3. they become apart of the completed weld

4. false

5. false

Task 4.15

1. d

2. because it requires careful attention to the distribution of heat on all surfaces to be welded

3. true

4. true

5. false

Task 4.16

1. c

2. when maximum strength is desired

3. make sure that the pool is protected at all times with the torch flame to prevent the formation of oxides and nitrides

4. true

5. false

Task 4.17

1. b

2. the number of weld passes necessary for a particular pipe joint should be determined by the rule of one weld pass for each 1/8 inch thickness of pipe wall over 3/16 inch

3. false - for the most part, pipe now is welded with the shielded metal-arc, gas metal-arc, or gas tungsten-arc processes

4. true - when beveled, 3/32 to 1/8 inch root opening, without beveling by spacing the pipe ends apart a distance equal to the wall thickness of the pipe

Task 4.17 (Con't.)

5. false - welding may be done in all positions with a single or multi-pass procedure and either the forehand or backhand technique

Task 4.18

1. b
2. d
3. c
4. a
5. b
6. c
7. flux
8. copper
9. true
10. true

UNIT 5.0

ARC WELDING
(Shielded Metal Arc Welding: SMAW)

SHIELDED METAL ARC WELDING (SMAW)

(ARC)

PREREQUISITE: None

OBJECTIVE: Shielded Metal Arc Welding (SMAW) is designed to develop entry level skills for the following classification.

Welder, Tack (DOT 810.684-010)
Welder, Shielded Metal
ARC (DOT 810.384-014)

The program graduate will perform the skills of striking the arc, maintain proper arc length, setting SMAW equipment, and manipulating the electrode. Skills will include welding square groove and fillet welds on mild steel sheet and plate.

Skills in ARC welding will include large multiples fillets and open root groove welds. Skills will be developed to perform high quality large multiples fillet welds and single V-groove welds on mild steel plate (open root) in the flat, horizontal, vertical, and overhead positions.

The SMAW training program graduate will be prepared to perform production, maintenance, and construction welding on light and heavy materials in all positions.

SUGGESTED STANDARDS FOR WELDING TRAINING

RECOMMENDED QUALIFICATION

POSITION:

(1G) Flat	Flat position groove welding of plate, pipe, and tubing, flat and horizontal position fillet welding of plate; and flat position fillet welding of pipe and tubing.
(2G) Horizontal	Flat and horizontal position groove and flat and horizontal position fillet welding of plate, pipe, and tubing.
(3G) Vertical	Flat, horizontal, and vertical position groove and flat, horizontal, and vertical position fillet welding of plate.
(4G) Overhead	Flat and overhead position groove and flat, horizontal, and overhead position fillet welding of plate.

85

WELDER QUALIFICATION: POSITION AND TYPE LIMITATIONS

Qualification Test		Type of weld and position of welding qualified			
		Plate		Pipe	
Weld	Metal Position	Groove	Fillet	Groove	Fillet
Plate-groove	1G (Flat)	F	F, H	F	F
	2G (Horizontal)	F, H	F, H	F, H	F, H
	3G (Vertical)	F, H, V	F, H, V		
	4G (Overhead)	F, O	F, H, O		
	3G & 4G	All	All		
Plate-fillet	1F		F		F
	2F		F, H		F, H
	3F		F, H, V		
	4F		F, H, O		
	3F & 4F		All		
Plate-groove	1G	F	F, H	F	F
	2G	F, H	F, H	F, H	F, H
	5G	F, V, O	F, V, O	F, V, O	F, V, O
	6G	Qualifies for all but groove welds for T-, Y-, and K- connections			
	2G & 5G				
	6G	All	All	All	All

F = flat
H = horizontal
V = vertical
O = overhead

Source: American Welding Society

SUPPLEMENT TO STANDARDS

ARC WELDING

The following descriptions may help standardized reporting of student competencies in arc welding.

	Level 4 Competency	Level 3 Competency	Level 2 Competency
1	a. Stringer beads -- no variation b Fillet welds -- contour of face is good depending on electrode type. Size of legs do not vary above or below the recommended lead size.	1. a. Little or no variation. b. Contour of face is good depending on electrode type. Size of legs may vary 1/16" or less above or below the recommended lead size.	1. a. Height and width may vary from bead to bead, but it would still be in the tolerance of acceptability. b. Fillet weld may vary from bead to bead also with leg size slightly smaller or larger and the contour of the face changing slightly from bead to bead.
2	Starting a weld -- starts good 100% of the time	2. Starts good 90% of the time	2. May be higher or wider or narrower, but also acceptable.
3	Uniform flux lines -- spacing and shaping are good. -- does not vary.	3. Spacing and shaping are good--may vary on occasion. (For example, 4 goods out of 5 times.)	3. Some rounded shapes and arrow shapes. Spacing would vary with speed or placement of the electrode in the puddle.
4	Tie-ins -- does not have a high buildup.	4. May have a high buildup sometimes, but still a good restart and on occasion, make a perfect restart.	4. Some tie-ins overlap crater properly or overlap too far.
5.	End of weld -- does not leave excessive metal buildup at end of crater. Never oversized.	5. May leave excessive metal buildup at end of crater but never oversize.	5. The crater not quite filled or overfilled.
6	Undercut -- no undercut or overlap	6. Very little, if any undercut--maybe a slight trace of overlap on occasion.	6. Slight undercut is okay within an acceptable tolerance and may be some overlap.
7	Excessive spatter -- arc length and amperage setting proper all of the time.	7. Arc length and amperage setting proper most of the time.	7. Fluctuating arc length and amperage setting.
8.	Dirty welds -- all clean welds.	8. No dirty welds.	8. Weld not always clean.

In reporting the proficiency of graduates, the following proficiency levels will be used:

Level

0 No skill demonstrated or proficiency training not given in skill.

1 Individual's skill level not that generally expected for entry level employment.

2 Individual's skill level probably is that generally expected for entry level employment, but the individual probably will need close on-the-job supervision for a while longer.

3 Individual's skill level is that generally expected for entry level employment.

4 Individual's skill level is equal to that of a worker with some on-the-job experience.

SUMMARY
ARC WELDING
SUGGESTED INSTRUCTION TIME

ARC WELDING UNIT/TASK		SUGGESTED HOURS
Unit 5.0		
5.01	Introduction (Principles) of Arc Welding	6
5.02	Safety in Arc Welding	6
5.03	Machines and Accessories	15
5.04	Select Electrode	4-6
5.05	Striking and Maintaining (Substaining) an Arc (Flat Position)	15
5.06	Chip Slag Using Chipping Hammer	1
5.07	Run Short Beads, Flat Position (Training Task)	160
5.08	Run Continuous Beads, Flat Position (Training Task)	**
5.09	Weld Weave Bead Pattern	**
5.10	Prepare Joint	4-6
5.11	Set Up and Make Stringer Beads on Flat Plate in All Positions (Dual Task Description) (E6010 and E7018 Electrodes)	185
5.12	Set Up and Tack Weld Joints: Butt, Tee, Lap, and Corner Joints (Dual Task Description)	185
5.13	Set Up and Multi-Pass Weld T-Joint, All Positions (Multi-Task Description)	185
5.14	Construct Open Butt Weld, All Positions	*
5.15	Construct Lap Joint Weld, 3/8 Inch Equal Legs, Three Passes	*
5.16	Construct An Outside Corner Weld in the Vertical Up and Down Positions	*
5.17	Construct Groove Weld on Pipe in Flat Axis, Vertical, and Diagonal Axis Positions	*

*Optional
**See Task 5.07

TASK LISTINGS
ARC WELDING

UNIT/TASK	DESCRIPTION
Unit 5.0	
5.01	(Introduction [Principles] of Arc Welding) Given instructions and an orientation to various welding processes, identify shielded metal arc welding as a process, describe the electric arc.
5.02	(Safety in Arc Welding) Given instructions concerning arc welding safety, demonstrate safety precautions recommended by the instructor and text (industry standards) concerning the handling of hot metal, high current electricity, toxic fumes, large quantities of ultraviolet rays, droplets of molten metals, and proper setting of arc welding machines.
5.03	(Machines and Accessories) Given instructions concerning machines and accessories for arc welding, demonstrate the proper procedures to set up given shielded metallic arc (arc) welding equipment to the instructor's standards (standards of industry or manufacturer).
5.04	(Select Electrode) Given an orientation to arc welding electrodes, select electrode and describe how to properly store and conserve electrodes during training.
5.05	(Striking and Maintaining [Substaining] an Arc [Flat Position]) Given instructions, safety protective equipment, welding machine-equipment-accessories, and 1/8 inch E6010 electrodes, and mild steel training plate, strike and maintain an arc to the instructor's standards.
5.06	(Chip Slag Using Chipping Hammer) Given a welded joint and chipping hammer; remove slag from weld. Weldment must be free of all removable slag.
5.07	(Run Short Beads, Flat Position [Training Task]) Given instructions, arc welding machine, safety equipment, accessories, mild steel plate, and electrode; run short beads to the instructor's standards. Flat position.
5.08	(Run Continuous Beads, Flat Position [Training Task]) Given instructions, arc welding machine-equipment-accessories (including safety clothing), electrode and metal plate; run continuous beads to the instructor's standards.

5.09 (Weld Weave Bead Pattern) Given a shielded metal arc welding station, mild steel coupons, electrode, personal safety equipment, and the necessary tools and materials; weld a weave bead pattern (as suggested by instructor) in the flat position. Weave bead must be 2-3 times the width of a stringer bead and should be made by weaving the electrode from side to side. A short dwell time at each side with rapid motion across the deposit will assure a flat weld with even ripple. Advance each time by 50 percent of deposit width.

5.10 (Prepare Joint) (See Task 4.06, Oxyacetylene Welding) Given metal to clean and prepare for welding, select the best joint and prepare the joint for arc welding.

5.11 (Set Up and Make Stringer Beads on Flat Plate in All Positions [Dual Task Description] [E6010 and E7018 Electrodes]), Given carbon steel plates, arc welding machine, safety equipment, and supplies; make stringer beads on flat plate in the flat position. Weld with (electrodes specified by the instructor): (a) 1/8 inch E6010 electrodes, or (b) 1/8 inch E7018 electrodes using the standard freehand method as specified by the instructor. Bead must be straight and uniform in height and width; have a uniform ripple formation; have no undercut, porosity, craters, or oxidation, and be fused with the base metal.

5.12 (Set Up and Tack Weld Joints: Butt, Tee, Lap, and Corner Joints [Dual Task Description]) Given instructions, arc machine, equipment, and accessories (a) E6010 1/8 inch or (b) E7018 1/8 inch electrode, steel plates; tack weld joints: Butt, T, Lap, and Corner. Tacks must be properly spaced between plates and sufficient to prevent distortion or warping from specifications.

5.13 (Set Up and Multi-Pass Weld T-Joint, All Positions [Multi-Task Description]) Given SMAW machine, equipment, and supplies, carbon steel plates to weld, fixture (jig) or overhead positioning, and (a) 1/8 inch E6010 or (b) 1/8 inch E7018 electrode; position plate and perform multi-pass welds in all* positions, running three (3) stringer beads on both sides of the T-Joint using the standard freehand method as specified by instructor. Visual inspection will show: (1) smooth and continuous welds; (2) 3/16 inch to 1/4 inch equal leg fillets; and (3) no cracks, undercutting, or overlap. *Flat, Vertical (up/down), and Horizontal.

5.14 (Construct Open Butt Weld, All Positions) Given a shielded metal arc welding station, mild steel coupons, electrodes, personal safety equipment, and the necessary tools and materials, construct open butt welds, 1/16 inch root opening, in all positions (flat, horizontal, vertical, and overhead). Bead must be straight and uniform in height and width; have no oxidation, weld must be fused with base metal and have full penetration.

5.15 (Construct Lap Joint Weld, 3/8 Inch Equal Legs, Three Passes) Given a shielded metal arc welding station, mild steel coupons, electrode, personal safety equipment, and the necessary tools and materials, construct a three pass lap joint weld, 3/8 inch equal legs. Beads must be straight and uniform in height and width; have a uniform ripple formation; and have no undercut, porosity, craters, or oxidation. Weld must be fused with base metal and show no visible penetration on opposite side of weld.

5.16 (Construct an Outside Corner Weld in the Vertical Up and Down Positions) Given a shielded metal arc welding station, electrode, mild steel coupons, personal safety equipment, and necessary tools and materials; construct an outside corner joint in the vertical up and down position. Bead must be straight and uniform in height and width; have a uniform ripple formation; and have no undercut, porosity, craters, or oxidation, weld must be fused with base metal and have full penetration.

5.17 (Construct Groove Weld on Pipe in Flat Axis, Vertical, and Diagonal Axis Positions) Given a shielded metal arc welding station, pipe, electrode, personal safety equipment, and the necessary tools and materials; construct a groove weld on pipe in the (a) flat axis position, (b) vertical position, and (c) diagonal axis position. The bead must be straight and uniform in height and width; have a uniform ripple formation; and have no undercut, porosity, craters, or oxidation. Weld must be fused with base metal and be smooth on inside of pipe.

NOTE

(For Tasks using 1/8 inch E7018 Electrode)

Task description 5.09 - 5.17 are "DUAL TASK DESCRIPTIONS" for (a) 1/8 inch E6010 Electrodes and (b) 1/8 inch E7018 Electrode.

If the electrodes are taught separately, the articulated, performance-based instruction guide may be turned back to Task 5.09 and references need to be made only to (b) descriptions.

UNIT	5.0	SHIELDED METAL-ARC WELDING (ARC WELDING)
TASK	5.01	INTRODUCTION (PRINCIPLES) OF ARC WELDING

PERFORMANCE OBJECTIVE:

Given instructions and an orientation to various welding processes, identify shielded metal arc welding as a process, describe the electric arc.

PERFORMANCE ACTIONS:

5.0101 Contrast shielded metal arc welding (SMAW) as a process compared to oxy-fuel, TIG, MIG, etc., welding processes.

5.0102 Describe the electric arc.

5.0103 Distinguish between AC and DC current.

5.0104 Describe how polarity is used in welding.

5.0105 Interpret and use the terminology of arc welding.

(NOTE: This performance action will occur during the entire training period of arc welding.)

5.0106 Describe standards for evaluation of competencies in arc welding.

PERFORMANCE STANDARDS:

- Identify SMAW as a process and interpret and use the terminology of arc welding to the standards established by the instructor.

SUGGESTED INSTRUCTION TIME: 6 Hours

RELATED TECHNICAL INFORMATION:

- Arc welding terminology.

ARC WELDING TERMINOLOGY

The suggested minimum terminology for arc welding is included for standardization and was taken from the following source:

Walker, John R. Arc Welding Basic Fundamentals, South Holland, IL: The Goodheart-Wilcox Company, Inc., pp. 122, 123, 1981.

AC (ALTERNATING CURRENT) — A current that reverses direction regularly as it rises and falls.

AMPERE — An electrical unit that indicates rate of flow of electricity through a circuit.

ARC LENGTH — Distance from end of electrode to surface of molten pool.

ARC VOLTAGE — Voltage across welding arc.

ARC WELDING — Process of joining metals by using heat of an electric arc, but without pressure.

BASE METAL — The metal to be welded.

BEVEL — Angle formed by a line or surface that is not at right angles to another line or surface.

BRITTLENESS — In some respects, opposite of toughness. The characteristic that causes metal to break easily.

BURR — Sharp edge remaining on metal after cutting, stamping or machining. A burr can be dangerous if not removed.

BUTT WELD — A weld made in the joint between two pieces of metal approximately in the same place.

CASEHARDENING — A process of surface hardening iron base alloys so that the surface layer or case is made substantially harder than interior or core.

CONTINUOUS WELD — A weld which extends without interruption for its entire length.

CRATER — Depression at end of a weld.

DC (DIRECT CURRENT) — Flow of electric current in one direction only.

DEPOSITED METAL -- Metal that has been deposited during welding.

DEPTH OF FUSION -- Distance that weld extends into base metal from its original surface.

EDGE PREPARATION -- Contour prepared on edge of a member for welding.

ELECTRODE -- A bare of flux coated wire or rod that is melted into base metal by an electric current passing through it.

ELECTRODE HOLDER -- Device used to hold and position the electrode.

FACE OF WELD -- Exposed surface of a weld, made by an arc or gas welding process, on the side from which the welding was done.

FATIGUE -- Tendency for metal to break or fracture under repeated or fluctuating stresses.

FILLER METAL -- Metal added to the weld.

FILLET WELD -- A weld approximately triangular in shape joining two surfaces approximately at right angles to each other in a lap joint, tee joint or corner joint.

FIXTURE -- A device for holding work in position or alignment while it is being welded.

FLAT POSITION -- Set-up where welding is performed from upper side of joint and face of weld is approximately horizontal. Sometimes called DOWNHAND WELDING.

FLUX -- Fusible material used in brazing and welding to dissolve and facilitate removal or oxides and other undesirable substances.

FUSION ZONE -- Area of base metal melted as determined by inspecting cross-section of a weld.

GROOVE WELD -- A weld made in groove between two members to be joined.

HARDENING -- Heating and quenching of certain iron base alloys to produce a hardness superior to that of untreated material.

HORIZONTAL POSITION -- Set-up where the weld is made in a horizontal plane and against an approximately vertical surface.

INCOMPLETE FUSION -- A weld in which there are voids between mating parts.

INTERMITTENT WELDING -- Pattern of welding where the continuity of the run is broken by unwelded spaces.

LAP JOINT -- A joint between two overlapping metal pieces.

LAY OUT -- To locate and scribe points for machining or forming operations.

LEG OF A FILLET WELD -- Distance from root of joint to toe of fillet weld.

MALLEABILITY -- Property of metal that determines ease with which it can be shaped when subjected to mechanical working (forging, rolling, etc.).

OVERHEAD POSITION -- Set-up where welding is performed from the underside of the joint.

OVERLAP -- Protrusion of weld metal beyond bond at toe of weld.

PASS -- A single welding operation along a joint or weld deposit. A weld bead results.

PENETRATION -- Distance the fusion zone extends below surface of part or parts being welded.

POROSITY -- Gas pockets or voids in the metal.

PUDDLE -- Portion of weld that is molten at place where heat is applied.

REVERSED POLARITY -- Arrangement of arc welding leads where the work is negative pole and electrode is positive pole of arc circuit.

ROOT OF WELD -- Points at which bottom of weld intersects base metal surfaces.

ROOT OPENING -- Spacing or separation between metal members to be joined at the root of the joint.

SLAG INCLUSION -- Nonmetallic solid material entrapped in weld metal or between weld metal and base metal.

SPATTER -- Metal particles expelled during arc or gas welding which do not form a part of the weld.

STANDARD -- An accepted base for a uniform system of measurement and quality.

STRING BEAD -- Type of weld bead made without a weaving motion.

STRINGER BEAD -- The initial bead, same as ROOT PASS.

TACK WELD -- A weld (generally short) made to hold parts in proper alignment until final welds are made. Used for assembly purposes only.

UNDERCUT -- A groove melted into base metal adjacent to toe of weld and left unfilled by weld metal.

UPHILL-WELDING -- A pipe welding term indicating that welds are made from bottom of pipe to top of pipe. The pipe is not rotated.

VERTICAL POSITION -- Set-up for welding where the axis of the weld is approximately vertical.

WEAVING -- A technique of depositing metal in which the electrode is moved in an oscillating motion.

WELDING MACHINE -- Equipment used to perform welding operation.

WHIPPING -- An inward movement of the electrode generally employed in vertical welding to avoid undercut.

STANDARD FOR EVALUATION OF COMPETENCIES

ARC WELDING

	AREA OF EVALUATION	WHAT TO LOOK FOR
1.	Size of welds	
	a. Stringer beads	Height and width
	b. Fillet welds	Size of legs, contour of weld face
2.	Starting a weld	Height and width same as rest of weld
3.	Uniform flux lines	Even spacing and round shape
4.	Tie-ins	Restarting a weld in a crater
5.	End of weld	Proper filling of a crater at the end of the weld
6.	Undercut	Groove at toes of weld
7.	Excessive spatter	Small balls of metal and slag around weld area
8.	Dirty welds	Improper cleaning during the after welding

UNIT 5.0 ARC WELDING

TASK 5.02 SAFETY IN ARC WELDING

PERFORMANCE OBJECTIVE:

Given instruction concerning arc welding safety, demonstrate safety precautions recommended by the instructor and text (industry standards) concerning the handling of hot metal, high current electricity, toxic fumes, large quantities of ultraviolet rays, droplets of molten metals, and proper setting of arc welding machines.

PERFORMANCE ACTIONS:

5.0201 Identify personal safety clothing and equipment.
- a. Describe personal clothing recommendations: High-top leather shoes with safety tips recommended and no canvas shoes, no cuffs in trousers and shirts without pockets recommended.
- b. Identify proper safety clothing and equipment to include:
  - Head shield (welding helmet) or hand shield
  - Proper lenses for ultraviolet and infrared rays and proper care of lenses
  - Gauntlet type gloves
  - Leather (or fire resistent) jacket, apron, or sleeves

5.0202
- a. Use tongs or pliers to handle hot metal.
- b. Cool hot metal in a quench tank or safe cooling area.

5.0203 Do not carry easily ignited materials such as butane lighters, matches, etc.

5.0204 Check welding area for proper ventilation.

5.0205 Check welding area to ensure the safety of others. Check to ensure safe housekeeping.

5.0206 Check to ensure the equipment and accessories are safe before starting.

PERFORMANCE STANDARDS:

- Demonstrate by written knowledge test and performance in training situations, proper safety precautions for arc welding, meeting the instructor's standards and standards accepted by the welding industry.
- "Zero" reportable injuries.

UNIT	5.0	ARC WELDING
TASK	5.02	SAFETY IN ARC WELDING (Con't.)

SUGGESTED INSTRUCTION TIME: 6 Hours

RELATED TECHNICAL INFORMATION:

- Proper care with flammable material around welding shop.
- Take care in damp or wet areas.
- Proper care in welding a tank or container, especially if it has contained flammable material in the past.

SAFETY IN ARC WELDING

The following "safety cautions" are quoted directly from the following publication and are recommended as a safety standard in arc welding training.

Giachino, Joseph W., Weeks, William. Welding Skills and Practices, Chicago, IL: American Technical Publishers, Inc., pp. 14-17, 1976.

1. "Install welding equipment according to provisions of the National Electric Code.

2. "Be sure a welding machine is equipped with a power disconnect switch which is conveniently located at or near the machine so the power can be shut off quickly.

3. "Don't make repairs to welding equipment unless the power to the machine is shut OFF.

4. "Don't use welding machines without proper grounding. Do not ground to pipelines carrying gases or flammable liquids.

5. "Don't use electrode holders with loose cable connectors. Keep connections tight at all times. Avoid using electrode holders with defective jaws or poor insulation.

6. "Don't change the polarity switch when the machine is under a load. Wait until the machine idles and the circuit is open.

7. "Don't operate the range switch under load. The range switch which provides the current setting should be operated only while the machine is idling and the current is open.

8. "Don't overload welding cables or operate a machine with poor connections.

9. "Don't weld in damp areas and keep hands and clothing dry at all times. Dampness on the body may cause an electric shock. Never stand or lie in puddles of water, on damp ground, or against grounded metal when welding without suitable insulation. Use a dry board or rubber mat to stand on.

10. "Don't strike an arc if someone without proper eye protection is nearby. Arc rays are harmful to the eyes and skin. If other persons must work nearby, the welding area should be partitioned off with a fire-retardant canvas curtain to protect them from the arc welding flash.

11. "Never pick up pieces of metal which have just been welded or heated.

12. "Always wear protective eye goggles when chipping or grinding.

13. "Don't weld on hollow (cored) casting unless they have been properly vented, otherwise an explosion may occur.

14. "Be sure press-type welding machines are effectively guarded.

15. "Be sure suitable spark shields are used around equipment in flash welding.

16. "When welding is completed, turn OFF the machine. If applicable, pull the power disconnect switch. Hang the electrode holder in its designated place."

UNIT 5.0 ARC WELDING

TASK 5.03 MACHINES AND ACCESSORIES

PERFORMANCE OBJECTIVE:

Given instruction concerning machines and accessories for arc welding, demonstrate the proper procedures to set up given shielded metallic arc (ARC) welding equipment to the instructor's standards (standards of industry or manufacturer).

PERFORMANCE ACTIONS:

5.0301 Identify basic types of arc welding machines.
- a. (1) AC
  (2) DC
  (3) AC/DC Rectifier
- b. Interpret advantages/uses of each type

5.0302 Locate major controls on different machines in training lab.

5.0303 Identify arc welding equipment accessories.
- a. Cables
- b. Ground clamp
- c. Electrode holder
- d. Electrodes
- e. Welding shield or helmet
- f. Personal safety clothing
- g. Hot metal handling tools
- h. Weld cleaning equipment

5.0304 Demonstrate proper procedures for setting up arc welding equipment.

PERFORMANCE STANDARDS:

- Set up arc welding equipment according to instructor's guidelines according to the type of welding to be done.

SUGGESTED INSTRUCTION TIME: 15 Hours

RELATED TECHNICAL INFORMATION:

- Safety precautions in operating machines.
- Manufacturer's instructions.

ARC WELDING EQUIPMENT

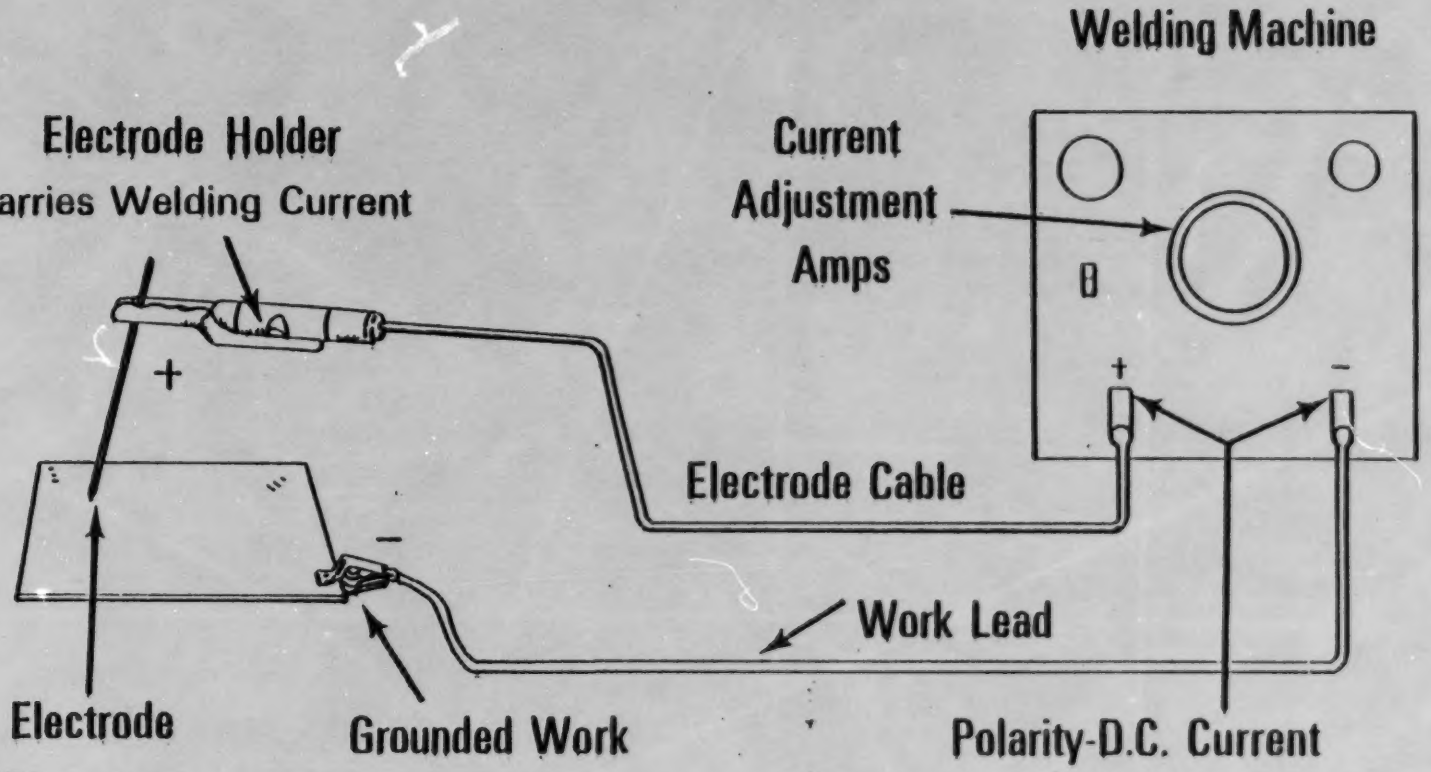
CHECKLIST

Check each item prior to starting any welding assignment. (The checklist may be used by the student or instructor.)

		Yes	No
1.	Machine is properly grounded.	( )	( )
2.	Cable ground clamp is properly secured.	( )	( )
3.	Main power switch is turned on for welding.	( )	( )
4.	The machine, of a motor generator, is set for correct polarity.	( )	( )
5.	The amperage control is set at the approximate current for the electrode to be used.	( )	( )
6.	The electrode holder is in good condition.	( )	( )
7.	The bench top is clean and dry.	( )	( )
8.	Welding gloves are available for use.	( )	( )
9.	Trainee is wearing proper protective clothing for welding.	( )	( )
10.	Clear cover glasses over the helmet lens are relatively free of metal spatter.	( )	( )
11.	The welding area is properly shielded.	( )	( )
12.	There is ample ventilation.	( )	( )
13.	Slag removal equipment is available.	( )	( )

Source: Giachino, Joseph W. Arc Welding, Alsip, IL: American Technical Publishers, Inc., 1977.

Welding Circuit



Diameters:
1/16 - 5/16 x 14'
Most Common
Length

Completes
Welding Circuit

Reverse:

1. Electrode (+)
2. Current flows from work to electrode
3. 2/3 heat at (+) electrode
   1/3 heat at (-) work

Straight:

1. Electrode (-)
2. Current flows from electrode to work
3. 2/3 heat at (-) work
   1/3 heat at (+) electrode

UNIT	5.0	ARC WELDING
TASK	5.04	SELECT ELECTRODE

PERFORMANCE OBJECTIVE:

Given an orientation to arc welding electrodes, select electrode and describe how to properly store and conserve electrodes during training.

PERFORMANCE ACTIONS:

5.0401 Describe the actions of electrodes in arc welding.

5.0402 Identify arc welding electrodes given by instructor.
a. E6010
b. E7018

5.0403 Explain how to properly store electrodes.

5.0404 Describe how to conserve electrodes in training.

5.0405 Demonstrate proper selection of electrodes for given welding jobs.

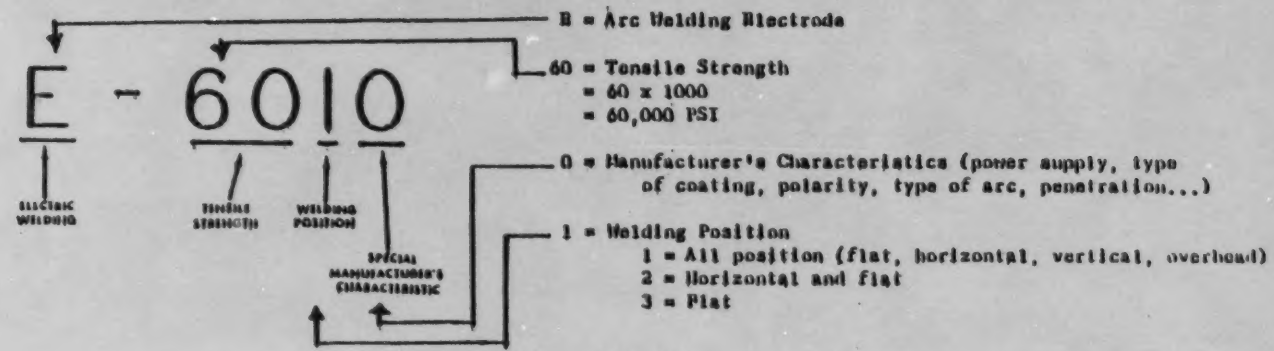
PERFORMANCE STANDARDS:

- Describe how to properly store electrodes and how to conserve electrodes in training. Demonstrate proper selection of electrodes, storage, and conservation.

SUGGESTED INSTRUCTION TIME: 4-6 Hours

CLASSIFICATION OF ELECTRODES

Example:


E - 6010
ELECTRIC WELDING
TENSILE STRENGTH
WELDING POSITION
SPECIAL MANUFACTURER'S CHARACTERISTIC
E = Arc Welding Electrode
60 = Tensile Strength
= 60 x 1000
= 60,000 PSI
0 = Manufacturer's Characteristics (power supply, type of coating, polarity, type of arc, penetration...)
1 = Welding Position
1 = All position (flat, horizontal, vertical, overhead)
2 = Horizontal and flat
3 = Flat

GENERAL CHARACTERISTICS OF SELECTED MILD STEEL ELECTRODES

CLASSIFICATION	WELDING CURRENT	WELDING POSITION	PENETRATION	SLAG	SPATTER	APPLICATION	WELD RESULTS	TYPICAL CURRENT SETTINGS FOR 1/8" ELECTRODES
E6010	DC Reverse	All	Deep	Thin	Moderate	Best all position electrode	Fast freeze, flat beads	80-120 Amps
E7018	AC-DC Reverse	All	Medium	Medium	Slight	For heat treated steel	Steel that tend to develop porosity and crack under weld bead	100-150 Amps

UNIT 5.0 ARC WELDING

TASK 5.05 STRIKING AND MAINTAINING (SUB-STAINING) AN ARC (FLAT POSITION)

PERFORMANCE OBJECTIVE:

Given instruction, safety protective equipment, welding machine-equipment-accessories, and 1/8" E-6010 electrodes, and mild steel training plate, strike and maintain an arc to the instructor's standards.

PERFORMANCE ACTIONS:

5.0501 Prepare for welding. (Take safety precautions included.)

5.0502 Set up given arc machine-equipment-accessories.

5.0503 Position plate.

5.0504 Correctly position electrode in holder and grip holder for welding.

5.0505 a. Strike and maintain an arc. (Use scratch, tapping, etc., method to produce acceptable arc.)
b. Adjust for proper heat.

PERFORMANCE STANDARDS:

- Strike and maintain an arc to the instructor's standards.

SUGGESTED INSTRUCTION TIME: 15 Hours

RELATED TECHNICAL INFORMATION:

- Operation of arc machine-equipment-accessories.
- Safety precautions.
- Electrode identification.

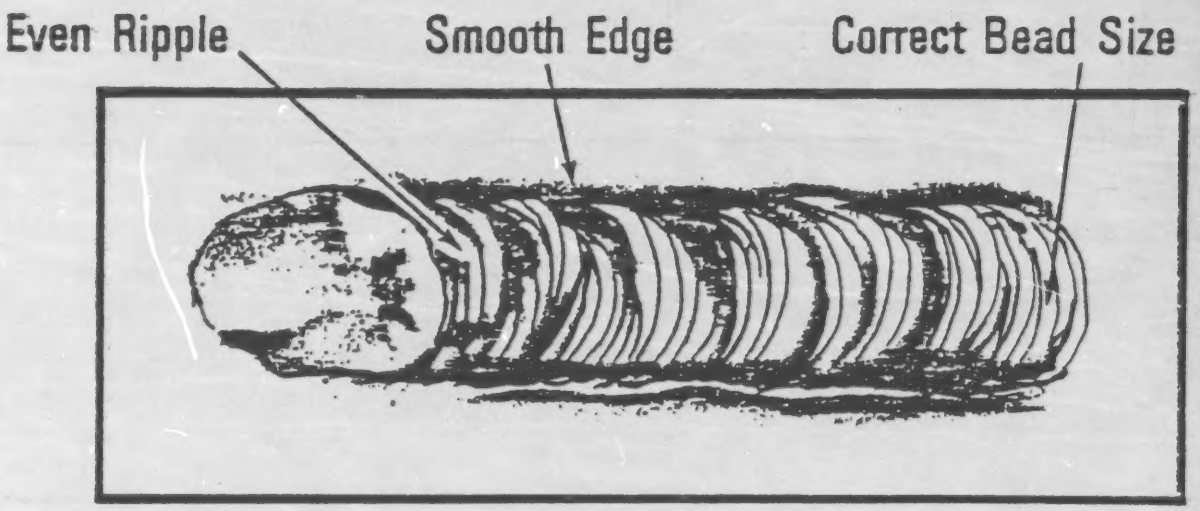
WELD ANALYSIS

CHECKLIST

	Yes	No
1. Bead width are right size.	( )	( )
2. Beads have uniform ripples.	( )	( )
3. Weld beads are too flat.	( )	( )
4. Weld beads are too high.	( )	( )
5. Weld penetration is insufficient.	( )	( )
6. Weld penetration is excessive.	( )	( )
7. Cold laps on surface.	( )	( )
8. Weld has surface porosity.	( )	( )
9. Weld has subsurface porosity.	( )	( )
10. Weld has crater cracks.	( )	( )
11. Weld has burn thru.	( )	( )
12. End crater is filled.	( )	( )
13. Weld passed bend test without cracking.	( )	( )

Source: Giachino, Joseph W. Arc Welding, Alsip, IL: American Technical Publishers, Inc., 1977.

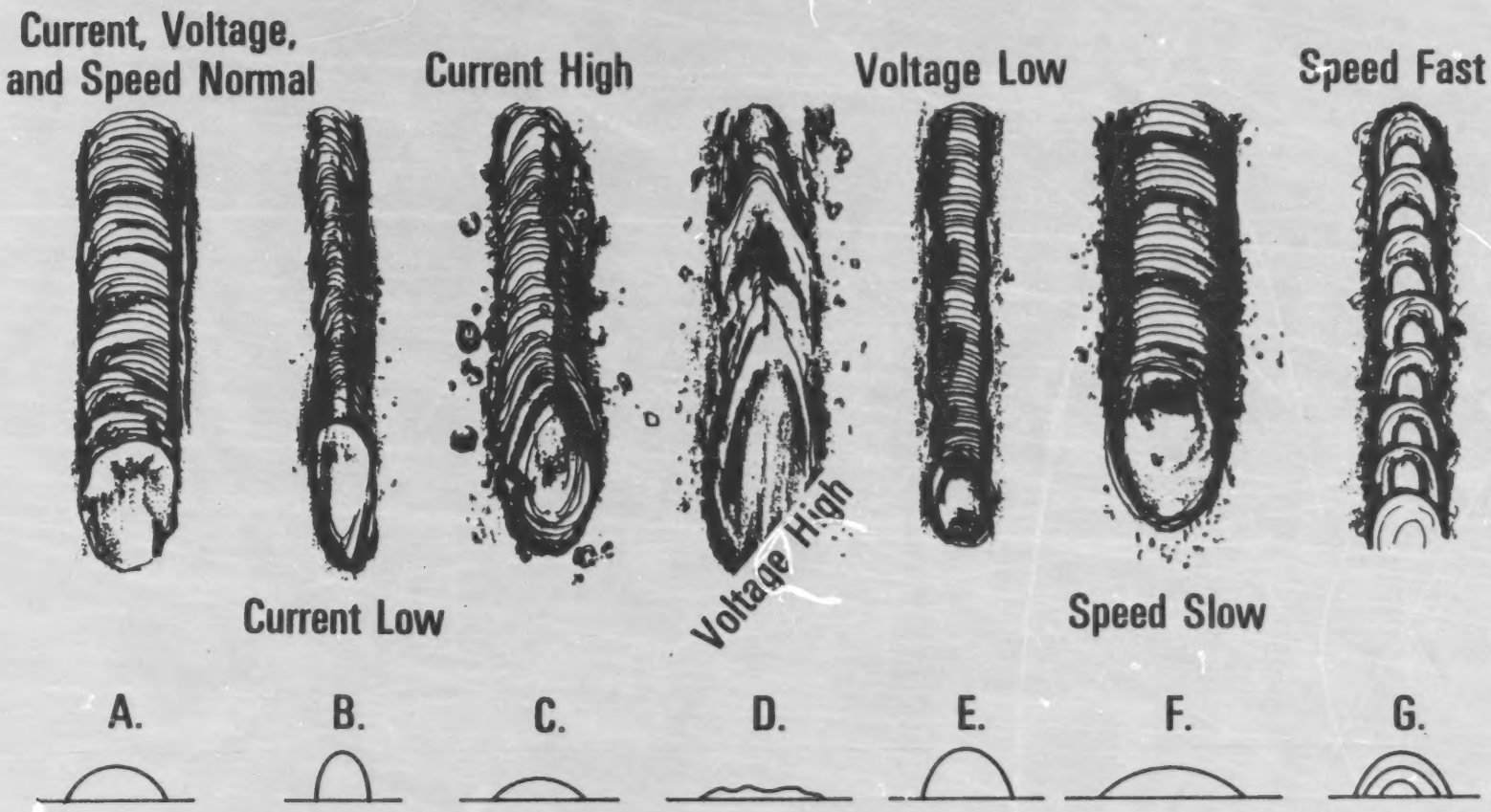
Example of a Good Weld



Clean, Bright Weld

Source: Welding, State Department of Vocational and Technical Education, Stillwater, Oklahoma.

Properly and Improperly Formed Beads



Source: Welding, State Department of Vocational and Technical Education, Stillwater, Oklahoma, 1974.

110

Addendum to Task 5.05

Causes of Poor Welds

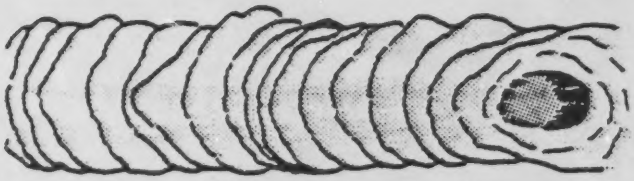
Welding Current Too Low
Welding Current Too High
Arc Too Long (voltage too high)
Welding Speed Too Fast
Welding Speed Too Slow

Source: Welding, State Department of Vocational and Technical Education, Stillwater, Oklahoma, 1974.

WELDING PROBLEMS— HOW TO SOLVE THEM

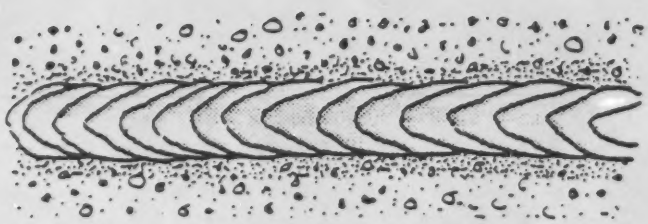
Taken from: Walker, John R., Arc Welding, Basic Fundamentals, South Holland, IL: The Goodheart-Wilcox Company, Inc., pp. 51-53, 1981.

POOR APPEARANCE



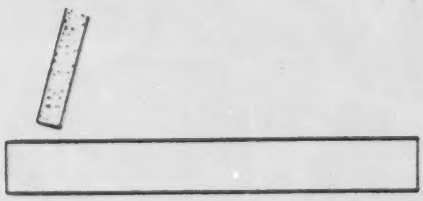
CAUSES	HOW TO SOLVE
1. Current setting too high or too low.	1. Correct current setting.
2. Wrong type of electrode.	2. Use proper electrode.
3. Faulty electrode.	3. Check electrodes before use.
4. Overheated work.	4. Allow work to cool between passes.
5. Incorrect speed of travel.	5. Adjust speed so that proper bead is formed.
6. Electrode manipulated improperly.	6. Use proper welding technique.

EXCESSIVE SPATTER



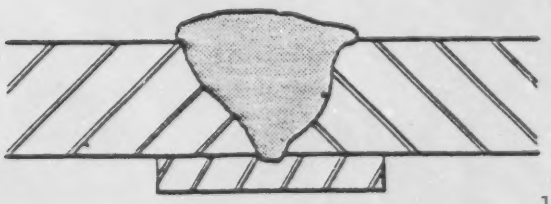
CAUSES	HOW TO SOLVE
1. Current setting too high.	1. Use correct current setting.
2. Arc too long.	2. Adjust to proper length arc.
3. Arc blow.	3. Minimize arc blow.
4. Wrong polarity for electrode being used.	4. Use correct electrode and polarity.
5. Faulty electrode.	5. Select suitable electrode.

ARC HARD TO START



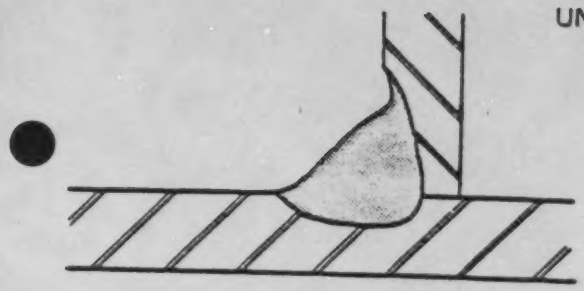
CAUSES	HOW TO SOLVE
1. Current setting too low.	1. Correct current setting.
2. Work not cleaned.	2. Clean work.
3. Work not properly grounded.	3. Clamp ground solidly to bare metal.
4. Flux covered electrode tip.	4. Clean electrode tip.

POOR FUSION



CAUSES	HOW TO SOLVE
1. Current setting too low.	1. Correct welding current.
2. Incorrect welding speed.	2. Adjust welding speed to insure melting of both sides of joint.
3. Wrong type electrode.	3. Use proper electrode.
4. Arc too long.	4. Hold correct length arc.
5. Work not properly prepared for welding.	5. Make sure joint is clean. "V" or groove joint if necessary.

UNDERCUTTING



CAUSES

1. Current setting too high.
2. Welding speed too fast.
3. Arc too long.
4. Wrong size electrode.
5. Incorrect electrode to work angle.
6. Faulty electrode manipulation.

HOW TO SOLVE

1. Correct welding current.
2. Reduce speed of travel.
3. Hold correct length arc.
4. Use correct size electrode.
5. Adjust electrode angle so that arc force will hold molten metal until undercut fills.
6. Use a uniform weave.

POROUS WELDS

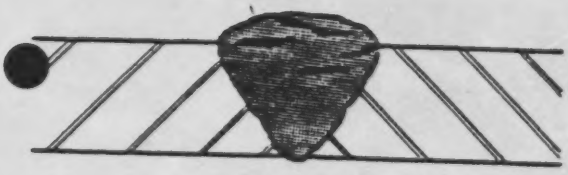
CAUSES

1. Short arc.
2. Welding speed too fast.
3. Welding speed too slow.
4. Insufficient puddling time.
5. Impurities in or on base metal.
6. Wrong type electrode.

HOW TO SOLVE

1. Hold correct length arc.
2. Reduce speed of travel.
3. Increase speed of travel.
4. Allow enough puddling time for gases to escape.
5. Clean base metal thoroughly.
6. Use proper electrode.

SLAG INCLUSION



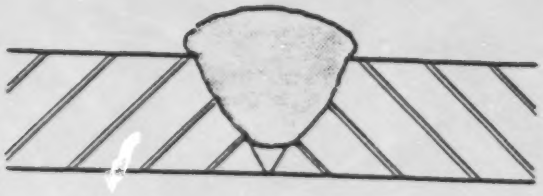
CAUSES

1. Current setting too low.
2. Arc too short.
3. Welding speed too slow.
4. Welding speed too fast.
5. Faulty electrode manipulation.

HOW TO SOLVE

1. Correct welding temperature.
2. Hold correct arc length.
3. Increase welding speed.
4. Decrease welding speed.
5. Use correct electrode to work angle so that arc force prevents molten metal from overtaking slag.

INCOMPLETE PENETRATION



CAUSES

1. Welding speed too fast.
2. Electrode too large.
3. Current setting too low.
4. Impurities in or on base metal.
5. Weld groove not proper size.

HOW TO SOLVE

1. Weld more slowly.
2. Select electrode according to welding groove size.
3. Correct welding current.
4. Clean base metal thoroughly.
5. Allow sufficient space at bottom of joint.

CRACKED WELDS

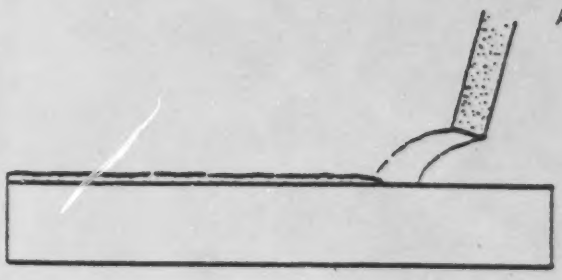
CAUSES

1. Wrong type electrode.
2. Base metal high carbon steel.
3. Weld cooled too rapidly.
4. Work too rigid.
5. Weld and parts sizes unbalanced.

HOW TO SOLVE

1. Use proper electrode.
2. Cool work slowly.
3. Cool work slowly.
4. Design work to eliminate rigid joints.
5. Heat parts before welding. Cool slowly after welding.

ARC BLOW



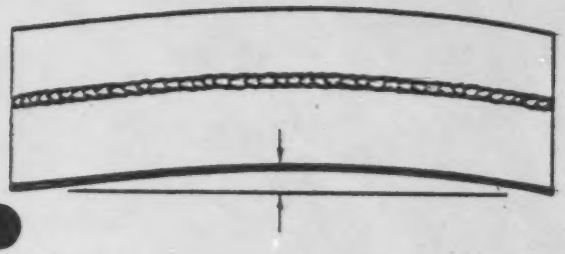
CAUSES

1. Magnetic fields cause the arc to wander from its intended course.

HOW TO SOLVE

1. Use steel blocks to alter magnetic path around arc.
2. Use AC machine.
3. Relocate ground connection.
4. Use very short arc and point electrode in direction of blow.
5. Weld away from ground.

WARPING



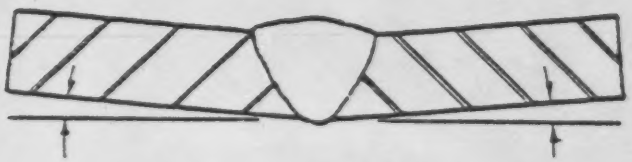
CAUSES

1. Shrinkage of weld metal.
2. Faulty clamping of parts.
3. Overheating of joint.
4. Faulty joint preparation.

HOW TO SOLVE

1. Use intermittent or skip weld.
2. Clamp parts properly.
3. Weld rapidly. Use high speed and moderate penetration electrodes.
4. Avoid excessive space between parts.

DISTORTION



CAUSES

1. Uneven heating.
2. Overheating.
3. Incorrect placement of parts to be joined.
4. Incorrect welding procedure.

HOW TO SOLVE

1. Tack or clamp parts properly.
2. Use short beads. Allow to cool between welds.
3. Adjust pieces so that they warp into position.
4. Use proper bead placement and welding sequence. Keep weld deposits at a minimum.

UNIT 5.0 ARC WELDING

TASK 5.06 CHIP SLAG USING CHIPPING HAMMER

PERFORMANCE OBJECTIVE:

Given a welded joint and chipping hammer; remove slag from weld. Weldment must be free of all removable slag.

PERFORMANCE ACTIONS:

5.0601 Prepare for chipping: Select safety equipment.

5.0602 Select chipping hammer.

5.0603 Chip slag from weld using side by side method.

5.0604 Brush to clean as required.

PERFORMANCE STANDARDS:

- Chip slag from freshly cooled weld so that all removable slag is freed.

SUGGESTED INSTRUCTION TIME: 1 Hour

RELATED TECHNICAL INFORMATION:

- Clean weld area thoroughly of all paint, scale, rust, etc.
- Uncleaned weld area is the common cause of slag.

UNIT	5.0	ARC WELDING
TASK	5.07	RUN SHORT BEADS, FLAT POSITION (TRAINING TASK)

PERFORMANCE OBJECTIVE:

Given instructions, arc welding machine, safety equipment, accessories, mild steel plate, and electrode; run short beads to the instructor's standards. Flat position.

PERFORMANCE ACTIONS:

5.0701 Prepare for arc welding (including safety precautions).

5.0702 Set up arc machine-equipment-accessories.

5.0703 Position plate.

5.0704
a. Run short beads in flat position to instructor's standards. (Scratch method recommended).
b. Examine weld bead (after each pass).
c. Adjust machine as necessary to produce a satisfactory bead.

5.0705 Clean weld after each pass.

PERFORMANCE STANDARDS:

- Run short beads to instructor's standards. Beads must be straight, with no undercut, no slag inclusions or porosity.
- Even ripple appearance.

SUGGESTED INSTRUCTION TIME: 160 Hours

RELATED TECHNICAL INFORMATION:

- Recognizing the sound of an arc that is:
  a. correct (continuous cracking, frying)
  b. too long (humming)
  c. or too short (popping)
- Identify desired puddle appearance.
- Check adjustment of welding heat.

UNIT	5.0	ARC WELDING
TASK	5.08	RUN CONTINUOUS BEADS, FLAT POSITION (TRAINING TASK)

PERFORMANCE OBJECTIVE:

Given instructions, arc welding machine-equipment-accessories (including safety clothing), electrode and metal plate; run continuous beads to the instructor's standards.

PERFORMANCE ACTIONS:

5.0801 Prepare for arc welding. (Machine, safety equipment, accessories, personal safety, etc.)

5.0802 Mark lines on steel plate and position plate for welding.

5.0803 Run a continuous bead, starting at left edge of work, using the full length of the electrode.

5.0804
a. Remove slag.
b. Examine weld.
c. Adjust machine if necessary.

5.0805 Suggested: At end of weld, stop bead by shortening arc and quickly backing or "whipping" electrode to break the arc.

(NOTE: Running a continuous bead will be repetitive process until the student becomes competent in the task.)

ADDITIONAL SKILL DEVELOPMENT TASKS IN RUNNING BEADS

1. Practice re-striking the arc while running continuous beads.
2. Practice padding.

PERFORMANCE STANDARDS:

- Run a continuous bead on given metal plate to the instructor's standards.
- Even ripple appearance.
- No undercut, porosity, slag inclusions.
- Proper penetration.

UNIT	5.0	ARC WELDING
TASK	5.08	RUN CONTINUOUS BEADS, FLAT POSITION (TRAINING TASK) (Con't.)

SUGGESTED INSTRUCTION TIME: See Task 5.07 (Continuation of Similar Training)

RELATED TECHNICAL INFORMATION:

- Proper use of electrode in striking the arc.

UNIT 5.0 ARC WELDING

TASK 5.09 WELD WEAVE BEAD PATTERN

PERFORMANCE OBJECTIVE:

Given a shielded metal arc welding station, mild steel coupons, electrode, personal safety equipment, and the necessary tools and materials; weld a weave bead pattern (as suggested by instructor) in the flat position. Weave bead must be 2-3 times the width of a stringer bead and should be made by weaving the electrode from side to side. A short dwell time at each side with rapid motion across the deposit will assure a flat weld with even ripple. Advance each time by 50 percent of deposit width.

PERFORMANCE ACTIONS:

5.0901 Prepare for ARC welding.

5.0902 Position plate for welding.

5.0903 Weld weave bead pattern(s) as specified by the instructor.

5.0904 Check weld(s).

PERFORMANCE STANDARDS:

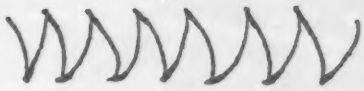
- Weld weave bead pattern(s) according to instructor's standards so that the weave is 2-3 times the width of a stringer bead and has even ripple.
- The instructor's standards applies.

SUGGESTED INSTRUCTION TIME: See Task 5.07 (Continuation of Similar Training)

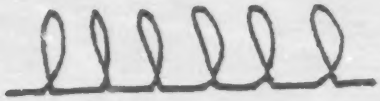
NOTE: See sample weave bead patterns on addendum page.

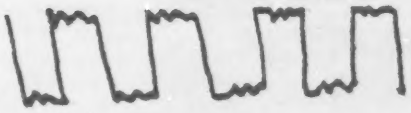
WEAVING MOTIONS

(May be chosen for building up weld, distributing heat more evenly, etc.)



Cresent





Box

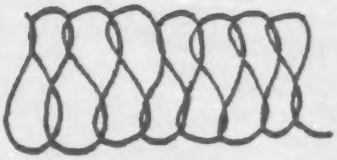
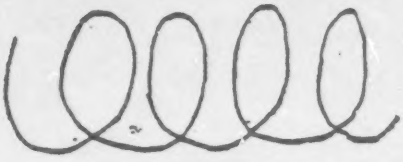
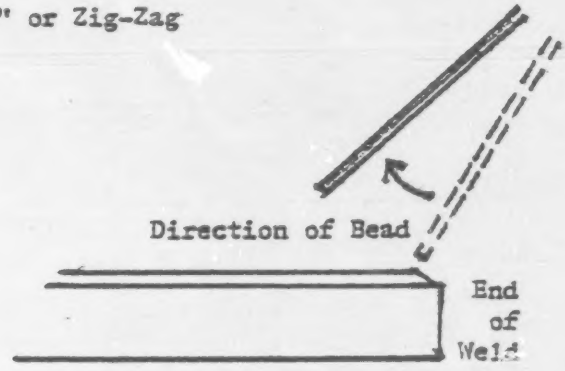


Figure 8

"Z" or Zig-Zag



Rotary



"Whipping" Electrode to Break Arc
(Stop bead by shortening the arc
and quickly backing electrode out.)

UNIT 5.0 ARC WELDING

TASK 5.10 PREPARE JOINT

PERFORMANCE OBJECTIVE:

(See Task 4.06, Oxyacetylene Welding) Given metal to clean and prepare for welding, select the best joint and prepare the joint for arc welding.

PERFORMANCE ACTIONS:

5.0801 Select type of joint. (It should be simplest joint to adequately do the job.)

5.0802 Prepare the joint so that the weld may penetrate close to 100 percent (deep penetration).

5.0803
a. Square butt.
b. Single bevel groove.
c. Single V groove.

5.0804 Clean and dry joints for welding.

PERFORMANCE STANDARDS:

- Prepare joints for welding meeting instructor's standards.

SUGGESTED INSTRUCTION TIME: 4-6 Hours

RELATED TECHNICAL INFORMATION:

- Review Task 4.06, Oxyacetylene Welding, as necessary.
- Metal characteristics.

SHIELDED METAL ARC WELDING

NOTE

The articulated, performance-based task descriptions that follow may vary slightly in format to permit a brief description of similar tasks.

Arc welding basically is represented by, but not limited to, the following organization:

1. Welding positions:
   a. Flat
   b. Horizontal
   c. Vertical
   d. Overhead

2. Welds and Joints:
   a. Butt (Flat plate)
   b. T-Joints
   c. Lap
   d. Corner

3. Electrodes used for training
   a. 1/8 inch E6010 Electrode
   b. 1/8 inch E7018 Electrode

4. Other positions, welds, joints, or electrode use may be specified by the instructor.

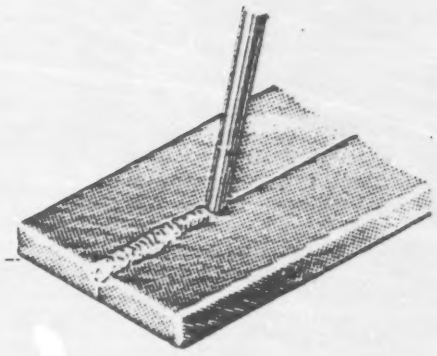
In the performance objective descriptions that follow, descriptors (a) = a, and (b) = b, and generally refer to the type of electrode being used (i.e., E6010 or E7018) and the technique of beading, etc.

When welding with E7018 electrode, the ROOT PASS may be made with the E6010 electrode and COVER PASSES then made with the E7018 electrode.

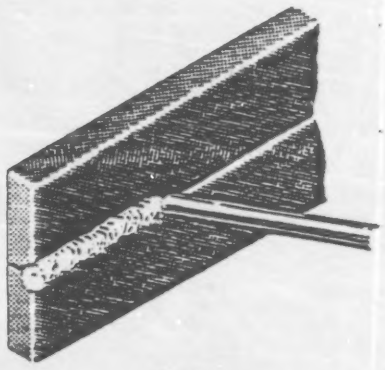
STANDARDIZATION OF TERMINOLOGY FOR ARC WELDING

The four main welding positions, referred to in this articulated, performance-based instruction guide, are:

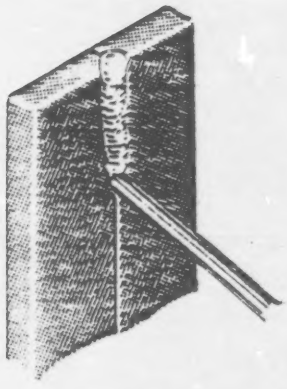
BASIC WELDING POSITIONS



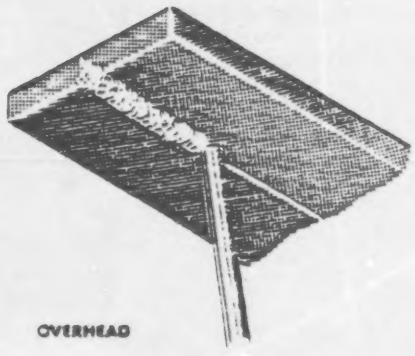
FLAT



HORIZONTAL



VERTICAL



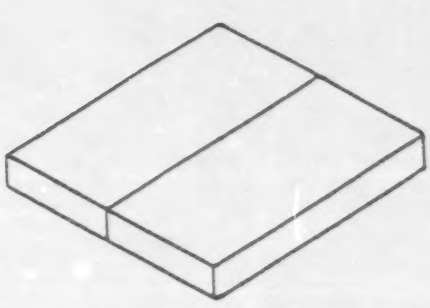
OVERHEAD

Giachino, Joseph M., Weeks, William. Welding Skills and Practices, Chicago, IL: American Technical Publishers, Inc., p. 50, 1976.

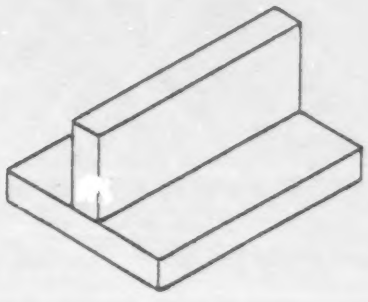
BASIC WELD JOINTS

The basic weld joints referred to in this articulated, competency-based instruction guide including the following:

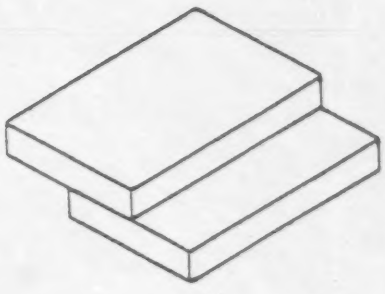
POSITIONING JOINTS FOR WELDING



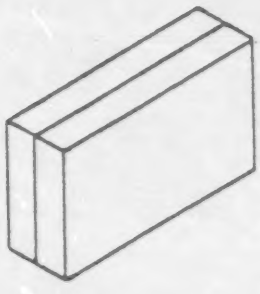
BUTT JOINT



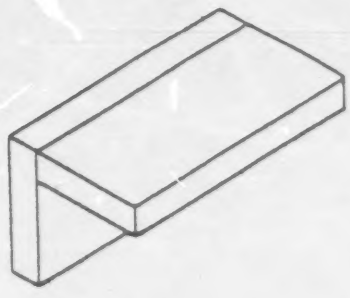
T-JOINT



LAP JOINT



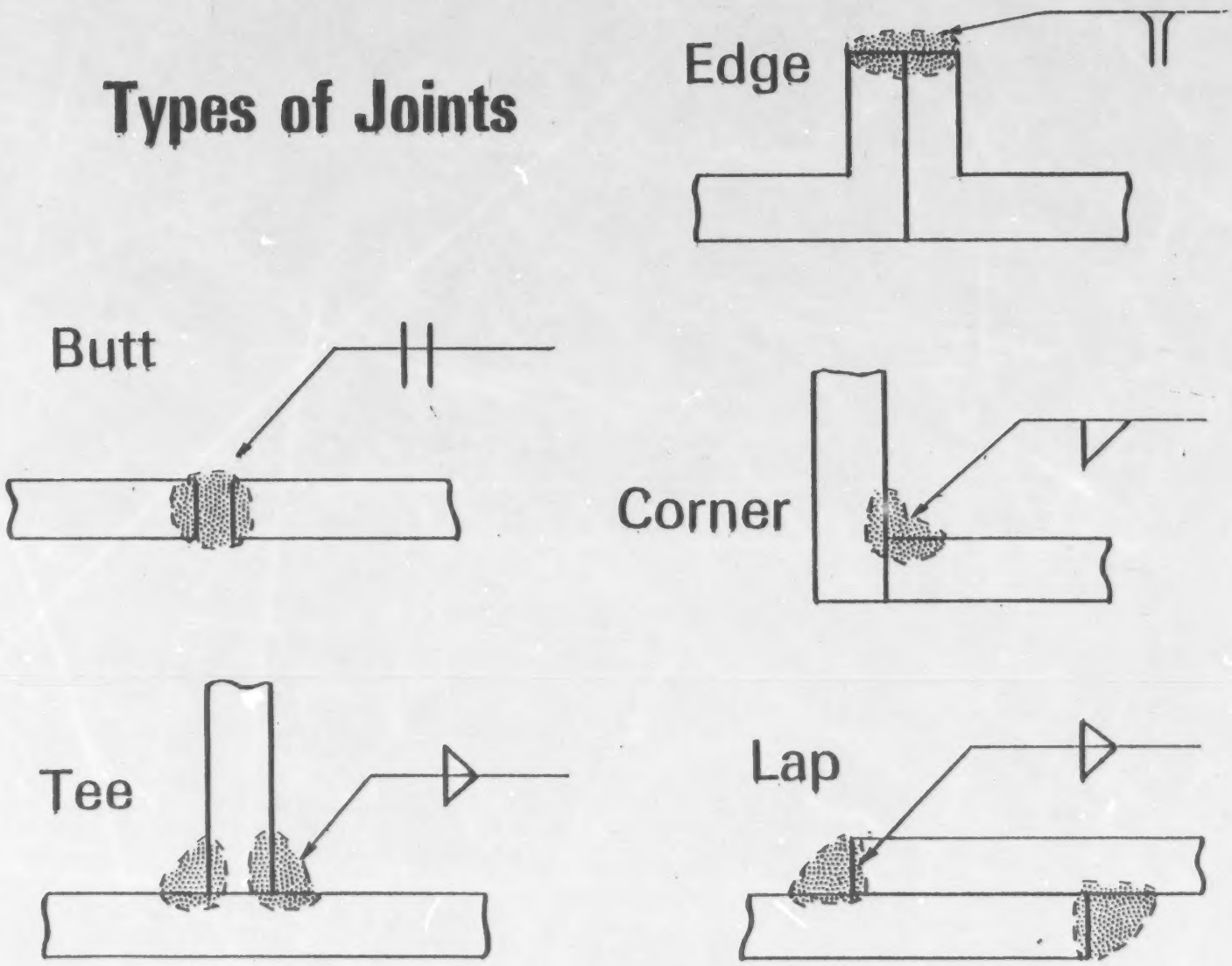
EDGE JOINT



CORNER JOINT

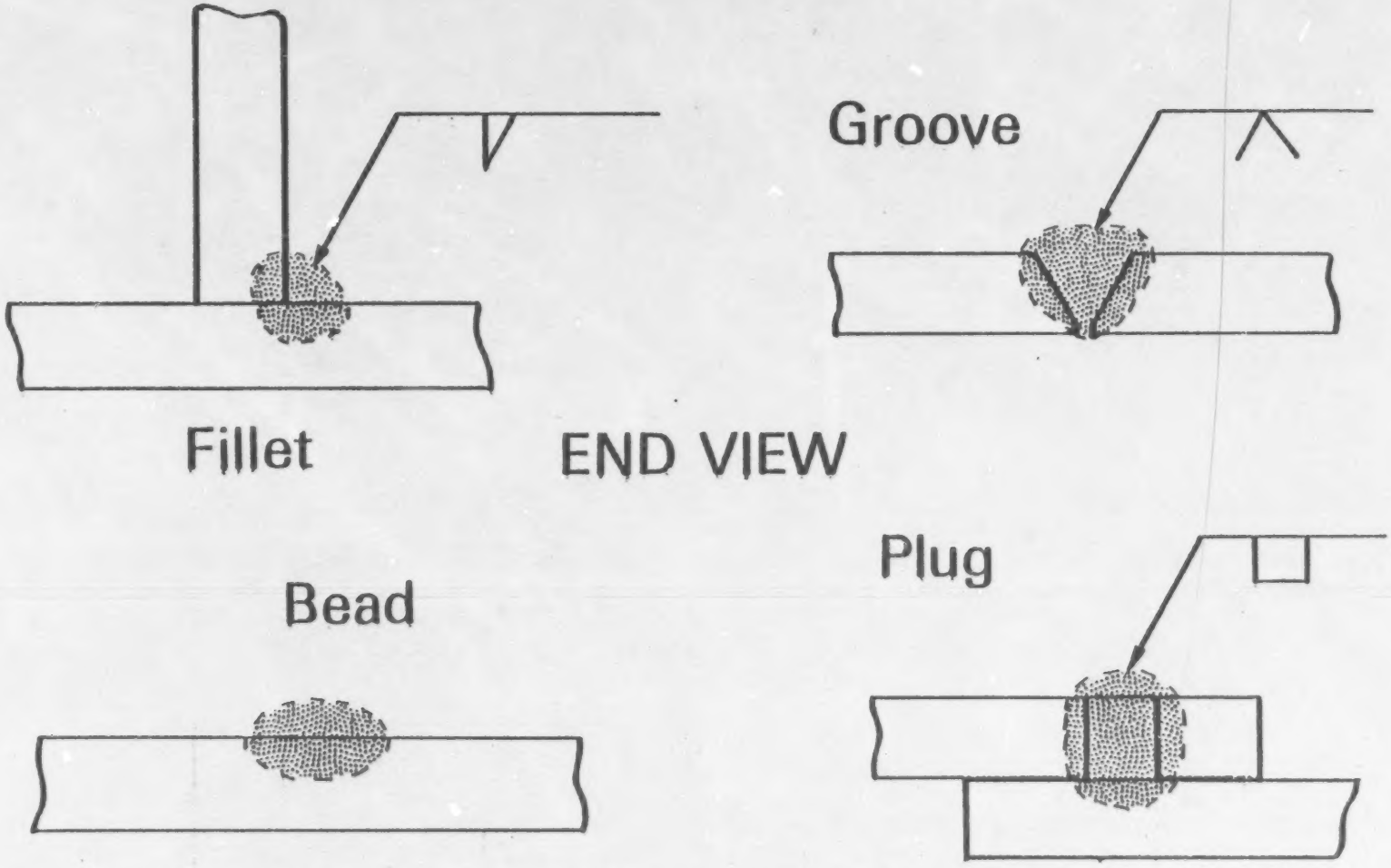
Walker, John R. Arc Welding Basic Fundamentals, South Holland, IL: The Goodheart-Wilcox, Inc., p. 15, 1981.

Types of Joints



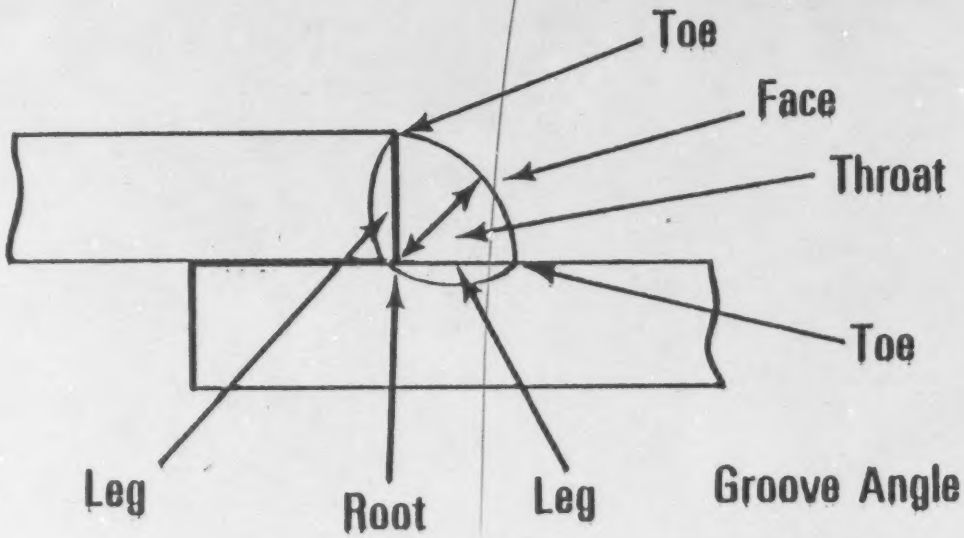
Source: Welding, State Department of Vocational and Technical Education, Stillwater, Oklahoma.

Types of Welds

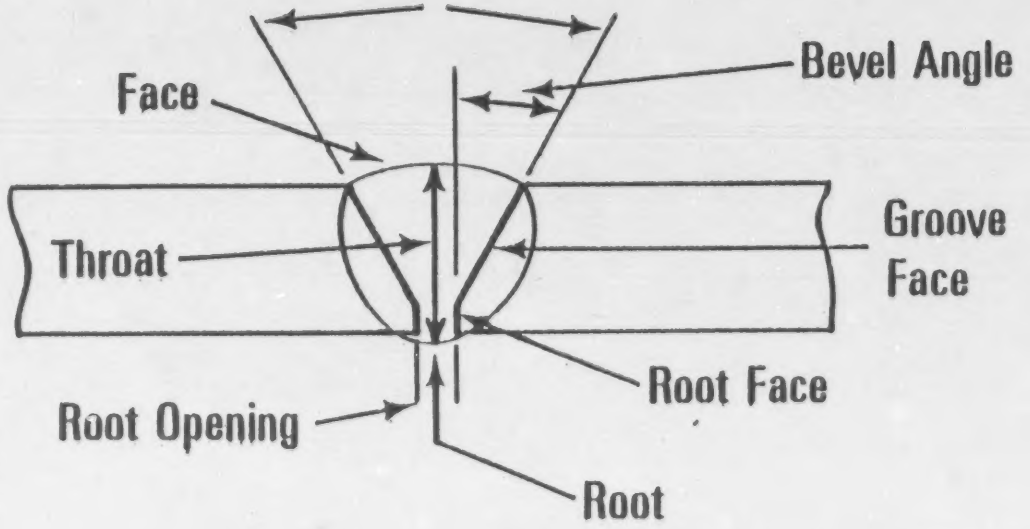


Source: Welding, State Department of Vocational and Technical Education, Stillwater, Oklahoma.

Parts of a Weld



FILLET WELD



GROOVE WELD

Source: Welding, State Department of Vocational and Technical Education, Stillwater, Oklahoma.

UNIT 5.0 ARC WELDING

TASK 5.11 SET UP AND MAKE STRINGER BEADS ON FLAT PLATE IN ALL POSITIONS (DUAL TASK DESCRIPTION) (E6010 and E7018 ELECTRODES)

PERFORMANCE OBJECTIVE:

Given carbon steel plates, arc welding machine, safety equipment, and supplies; make stringer beads on flat plate in the flat position. Weld with (electrodes specified by the instructor): (a) 1/8 inch E6010 electrodes, or (b) 1/8 inch E7018 electrodes using the standard free-hand method as specified by the instructor. Bead must be straight and uniform in height and width; have a uniform ripple formation; have no undercut, porosity, craters, or oxidation, and be fused with the base metal.

PERFORMANCE ACTIONS:

5.1101 Set up arc welding equipment and prepare for welding.

5.1102 Clean and position T-Joint for weld.

5.1103 Tack weld.*

5.1104 Run stringer beads.* All positions.

*Task and task actions are the same except for the electrode variables: (a) 1/8 inch E6010 electrode and (b) 1/8 inch E7018 electrode.

PERFORMANCE STANDARDS:

- Make horizontal fillet welds using, as directed by instructor:
  a. 1/8 inch E6010 electrodes
  b. 1/8 inch E7018 electrodes
- Visual inspection of welds should show:
  a. smooth and continuous welds
  b. 3/16 inch to 1/4 inch equal leg fillet welds
  c. no cracking, undercutting, or overlap
- Bead must be straight and uniform in height and width; have a uniform ripple formation; have no undercut, porosity, craters, or oxidation, and be fused with the base metal.

UNIT	5.0	ARC WELDING
TASK	5.11	SET UP AND MAKE STRINGER BEADS ON FLAT PLATE IN ALL POSITIONS (DUAL TASK DESCRIPTION) (E6010 and E7018 ELECTRODES) (Con't.)

SUGGESTED INSTRUCTION TIME: 185 Hours

RELATED TECHNICAL INFORMATION:

- Defective Welding and Recommended Corrective Action.
- Porosity (Gas Pockets): Caused by not allowing trapped gas to escape before the metal hardens.
- Inclusions: Caused by allowing the wrong kind of filler metal to enter the base weld metal.
- Non-metallic—Inclusions (SLAG): Caused by impurities from the electrodes and base metal, or the air becoming trapped in the weld metal.
- Cracks: Caused by too much porosity, slag or by sudden temperature changes which do not let the metal crystals form properly.

UNIT	5.0	ARC WELDING
TASK	5.12	SET UP AND TACK WELD JOINTS: BUTT, TEE, LAP, AND CORNER JOINTS (DUAL TASK DESCRIPTION)

PERFORMANCE OBJECTIVE:

Given instructions, arc machine, equipment, and accessories (a) E6010 1/8 inch or (b) E7018 1/8 inch electrode, steel plates; tack weld joints: Butt, T, Lap, and Corner. Tacks must be properly spaced between plates and sufficient to prevent distortion or warping from specifications.

PERFORMANCE ACTIONS:

5.1201 Prepare for arc welding.

5.1202 Position steel plates in joint configuration: (a) Butt, (b) Tee, (c) Lap, and (d) Corner.

5.1203 Tack weld plates into joint configuration.

(NOTE: Tack welding of plates may be omitted from following task descriptions but will be an action as part of positioning plates for welding.)

5.1204 Inspect tack weld for proper joint alignment; correct as necessary.

PERFORMANCE STANDARDS:

- Tack welds will be properly spaced between plates, with sufficient tacks to prevent distortion or warping as per specifications.
- Tack weld plates into joint configuration to instructor's standards.
- Tack weld should be fused firmly into the joint.

SUGGESTED INSTRUCTION TIME: 185 Hours

RELATED TECHNICAL INFORMATION:

- Tack weld.
- Joint configurations.
- Edge joint may be included/omitted depending upon skill needs of student, availability of materials, etc.

UNIT 5.0 ARC WELDING

TASK 5.13 SET UP AND MULTI-PASS WELD T-JOINT, ALL POSITIONS (MULTI-TASK DESCRIPTION)

PERFORMANCE OBJECTIVE:

Given SMAW machine, equipment, and supplies, carbon steel plates to weld, fixture (jig) for overhead positioning, and (a) 1/8 inch E6010 or (b) 1/8 inch E7018 electrode; position plate and perform multi-pass welds in all* positions, running three (3) stringer beads on both sides of the T-Joint using the standard freehand method as specified by instructor. Visual inspection will show: (1) smooth and continuous welds; (2) 3/16 inch to 1/4 inch equal leg fillets; and (3) no cracks, undercutting, or overlap.

*- Flat
- Vertical (up/down)
- Horizontal

PERFORMANCE ACTIONS:

5.1301 Prepare for welding. Select safety equipment.

5.1302 Set up SMAW machine, equipment, and supplies, including overhead fixture (jig).

5.1303 Clean and position plate into T-Joint, tack weld, and place in desired position.
a. Flat
b. Horizontal
c. Vertical (up/down)

5.1304 Multiple pass weld joints to specifications.

PERFORMANCE STANDARDS:

- Perform equal-leg multi-pass fillet welds in all positions, T-Joint.
- Visual inspection should show:
  1. smooth and continuous welds
  2. 3/8 inch to 1/2 inch equal leg fillet welds
  3. little or no sag (overlap) on vertical member of T-Joint
  4. no cracks or undercut
- Beads must be straight and uniform in height and width; have uniform ripple formation; have no undercut, porosity, craters, or oxidation; and must be fused with base metal.

UNIT	5.0	ARC WELDING
TASK	5.13	SET UP AND MULTI-PASS WELD T-JOINT, ALL POSITIONS (MULTI-TASK DESCRIPTION) (Con't.)

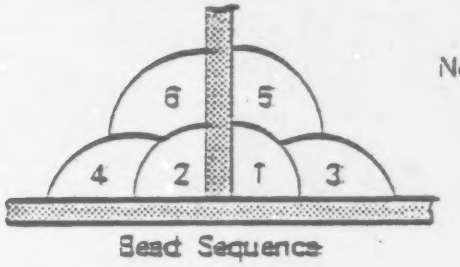
SUGGESTED INSTRUCTION TIME: 185 Hours

(NOTE: See addendum page for additional standards, etc.)

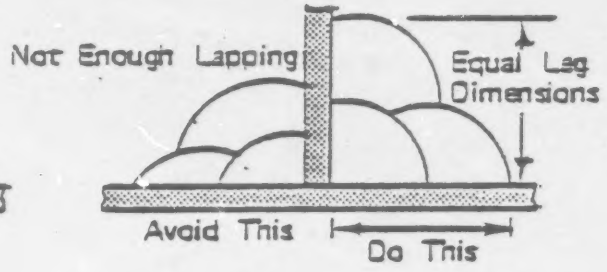
SUGGESTED STANDARDS FOR MULTI-PASS WELDS

1. On starting the multi-pass weld, hold a high arc for 1-2 seconds allowing end of metal plates to heat prior to depositing the proper bead (preventing cold tap).

2. Alternate root and cover passes from one side to another of the T-Joint to minimize distortion of the plates.



Bead Sequence

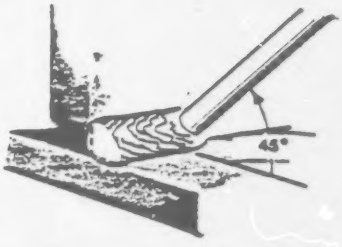


Keep Bead Dimensions Constant

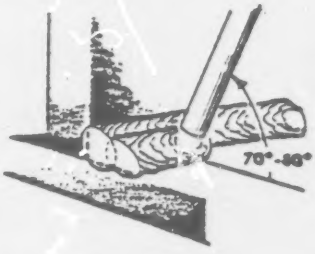
3. Remove slag from beads prior to laying a second bead (at the weld).

4. Keep bead dimensions constant.

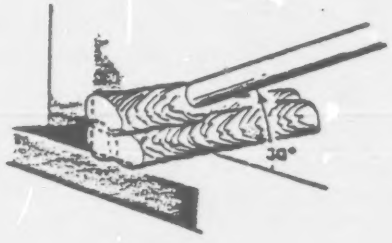
5. Observe recommended electrode angles.



FIRST BEAD



SECOND BEAD



THIRD BEAD

UNIT	5.0	ARC WELDING
TASK	5.14 (OPTIONAL)	CONSTRUCT OPEN BUTT WELD, ALL POSITIONS

PERFORMANCE OBJECTIVE:

Given a shielded metal arc welding station, mild steel coupons, electrodes, personal safety equipment, and the necessary tools and materials, construct open butt welds, 1/16 inch root opening, in all positions (flat, horizontal, vertical, and overhead). Bead must be straight and uniform in height and width; have no oxidation, weld must be fused with base metal and have full penetration.

PERFORMANCE ACTIONS:

5.1401 Prepare for ARC welding; select safety equipment.

5.1402 Set up SMAW machine, equipment, and supplies, and overhead fixture (jig) as applicable.

5.1403 Clean and position plate in proper configuration and position.

5.1404 Tack weld plates into position.

5.1405 Construct open butt weld, all positions, to specifications.

PERFORMANCE STANDARDS:

- Construct open butt weld, all positions, to specifications, so that the bead is straight and uniform in height and width, there is no oxidation, the weld is fused with base metal, and there is full penetration.
- The instructor's standards must be met.

SUGGESTED INSTRUCTION TIME: Optional

UNIT	5.0	ARC WELDING
TASK	5.15	CONSTRUCT LAP JOINT WELD, 3/8 INCH EQUAL LEGS, THREE PASSES

PERFORMANCE OBJECTIVE:

Given a shielded metal arc welding station, mild steel coupons, electrode, personal safety equipment, and the necessary tools and materials, construct a three pass lap joint weld, 3/8 inch equal legs. Beads must be straight and uniform in height and width; have a uniform ripple formation; and have no undercut, porosity, craters, or oxidation. Weld must be fused with base metal and show no visible penetration on opposite side of weld.

PERFORMANCE ACTIONS:

5.1501 Prepare for ARC welding.

5.1502 Set up SMAW machine, equipment, and supplies, and (jig), as applicable.

5.1503 Clean and position plate in proper configuration, position.

5.1504 Tack weld.

5.1505 Make multiple passes to weld lap joint as specified.

PERFORMANCE STANDARDS:

- Construct lap joint weld, 3/8 inch equal legs, three passes.
- Beads must be straight and uniform in height and width; have a uniform ripple formation; and have no undercut, porosity, craters, or oxidation.
- Weld must be fused with base metal and show no visible penetration on opposite side of weld.

SUGGESTED INSTRUCTION TIME: Optional

UNIT 5.0 ARC WELDING

TASK 5.16 (Optional) CONSTRUCT AN OUTSIDE CORNER WELD IN THE VERTICAL UP AND DOWN POSITIONS

PERFORMANCE OBJECTIVE:

Given a shielded metal arc welding station, electrode, mild steel coupons, personal safety equipment, and necessary tools and materials; construct an outside corner joint in the vertical up and down position. Bead must be straight and uniform in height and width; have a uniform ripple formation; and have no undercut, porosity, craters, or oxidation, weld must be fused with base metal and have full penetration.

PERFORMANCE ACTIONS:

5.1601 Prepare for welding.

5.1602 Sew up SMAW machine, equipment, and supplies, including (jig), if applicable.

5.1603 Clean and position plates in configuration, and position and tack weld.

5.1604 Construct an outside weld in vertical up and down positions, to specifications.

PERFORMANCE STANDARDS:

- Construct an outisde corner weld in the vertical up and down positions, to specifications.
- Bead must be straight and uniform in height and width; have a uniform ripple formation; and have no undercut, porosity, craters, or oxidation, weld must be fused with base metal and have full penetration.
- Performance must be to instructor's standards.

SUGGESTED INSTRUCTION TIME: Optional

UNIT	5.0	ARC WELDING
TASK	5.17 (Optional)	CONSTRUCT GROOVE WELD ON PIPE IN FLAT AXIS, VERTICAL, AND DIAGONAL AXIS POSITIONS

PERFORMANCE OBJECTIVE:

Given a shielded metal arc welding station, pipe, electrode, personal safety equipment, and the necessary tools and materials; construct a groove weld on pipe in the (a) flat axis position, (b) vertical position, and (c) diagonal axis position. The bead must be straight and uniform in height and width; have a uniform ripple formation; and have no undercut, porosity, craters, or oxidation. Weld must be fused with base metal and be smooth on inside of pipe.

PERFORMANCE ACTIONS:

5.1701 Prepare for welding; select safety equipment.

5.1702 Set up welding machine, equipment, and supplies, including any "jig" used.

5.1703 Clean and position pipe to be welded.
(NOTE: Position in flat axis, vertical, and diagonal positions as directed by the instructor.)

5.1704 Make groove weld on pipe.

PERFORMANCE STANDARDS:

- Construct groove weld on pipe in flat axis, vertical, and diagonal axis positions.
- Bead must be straight and uniform in height and width, have a uniform ripple formation, and have no undercut, porosity, craters, or oxidation.
- Weld must be fused with base metal and be smooth on inside of pipe.
- The instructor's standards must be met.

SUGGESTED INSTRUCTION TIME: Optional

RELATED TECHNICAL INFORMATION:

- Identify relevant safety precautions in pipe welding.
- Determine electrode type/size and current setting for pipe welding.
- Demonstrate/explain pipe bevelling techniques.
- Demonstrate/explain surface preparation procedures.

CHECKLIST FOR SMAW WELDS

CHECK TO INDICATE THAT THE STUDENT HAS COMPLETED THE WELD TO INDUSTRY STANDARDS (Omit otherwise)

	Flat					Horizontal					Vertical					Overhead					Pipe		
	Stringer	Butt	T	Lap	Corner	Stringer	Butt	T	Lap	Corner	Stringer	Butt	T	Lap	Corner	Stringer	Butt	T	Lap	Corner	Flat	Vertical	Diagonal
1. Even bead.																							
2. Even ripples in bead.																							
3. Bead uniform in width.																							
4. Bead height not excessive.																							
5. No holes in weld.																							
6. Weld not brittle.																							
7. No excessive metal under joint.																							
8. Proper penetration.																							
9. No cracks.																							
10. End crater filled.																							
11. No cold overlaps along joint seam.																							
12. Good fusion.																							
13. No undercutting.																							
14. No porosity.																							

UNIT 5.0 - ARC WELDING

OUTCOME-REFERENCED TESTS

Task 5.01

1. Identify which two polarities make AC Polarity.

_____ a. DCRP & AC
b. DCRP & DCSP
c. AC & DC
d. both b and c

2. Identify which element is not necessary to sustain an ARC.

_____ a. ARC gap
b. ARC voltage
c. load current
d. machine manufacture

3. Identify the actual voltage range used to provide welding current.

_____ a. 18-36 volts
b. 15 volts
c. 10 volts
d. 5 volts

4. Describe the difference between AC and DC current.

_____

5. Explain why different polarities are used in welding.

_____

UNIT 5.0 - ARC WELDING

OUTCOME-REFERENCED TESTS

Task 5.02

1. List 10 items of safety clothing and equipment in Arc welding.

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____
   6. _____
   7. _____
   8. _____
   9. _____
   10. _____

2. Explain why matches and butane lighters should not be carried in the welders clothing.

   _____

3. Why should a respirator be worn when noxious fumes are given OFF during the welding process.

   _____

4. Describe why heat-hardened gloves create a danger while using the side grinder.

   _____

UNIT 5.0 - ARC WELDING

OUTCOME-REFERENCED TESTS

Task 5.03

1. List at least five welding accessories used in Arc welding.

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____

2. List the different types of polarity that a rectifier welding machine is able to produce.

   _____ a. AC
   b. DC
   c. DC straight
   d. all the above

3. List the different types of polarity that a generator type welding machine is able to produce.

   _____ a. AC
   b. DC
   c. DC straight
   d. all the above

4. With what type welding machine is polarity of no consequence.

   _____

5. Given a booth and welding machine, demonstrate the proper procedure for setting up Arc welding equipment.

Task 5.04

1. Indicate which series electrode should be used when higher weld strengths are needed.

   _____ a. E60XX series
   b. E70XX series
   c. Nickel alloy
   d. none of the above

2. Identify which electrodes are used for most pipe welding.

   _____ a. E6010 or E6011
   b. E6012 or 70S-2
   c. E6012 or E6013
   d. best rod suited for job

3. Which of the following listed electrodes would be used for welding high carbon steel.

   _____ a. E7018
   b. E6010
   c. E6011
   d. E6012

4. State the two most common kinds of mild steel electrodes.

   _____

   _____

5. What do the first two digits of a E6010 electrode represent?

   _____

UNIT 5.0 - ARC WELDING

OUTCOME-REFERENCED TESTS

Tasks 5.05 and 5.06

1. List the 5 basic steps recommended in setting up an Arc welding machine.

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____

2. List 4 safety steps to take before Arc welding.

   1. _____
   2. _____
   3. _____
   4. _____

3. When should a weld be brushed?

   _____

4. Describe what article should be worn when chipping slag?

   _____

5. Demonstrate, on a given piece of steel, striking and maintaining an Arc.

Task 5.07

1. To sustain a stable arc, you need _____.

   _____ a. arc gap
   b. arc voltage
   c. load current
   d. all the above

2. A long arc unfortunately produces a:

   _____ a. unstable arc, reduces penetration, increases spatter, reduces the gas shield, and causes flat and wide beads
   b. stable arc, good penetration, increases spatter, reduces the gas shield, and causes flat and wide beads
   c. narrow bead, reduces penetration, increases spatter, reduces the gas shield, and causes flat and wide beads
   d. unstable arc, reduces penetration, increases spatter, increases the gas shield, and causes flat and wide beads

3. In striking an arc, if the electrode is allowed to remain in contact with the metal, the electrode will:

   _____ a. not stick to the base metal
   b. break loose
   c. cause a flash
   d. become red hot

4. When making current adjustments, turn the welding machine-up or down:

   _____ a. 5 amps
   b. 10 amps
   c. 15 amps
   d. 20 amps

5. The methods used to strike an arc are the tapping and the _____ motion.

6. A _____ noise indicates the current is set properly and the arc is at the right length.

7. An arc that is too _____ fails to generate enough heat to melt the base metal properly.

8. Always keep the jaws of the electrode holder _____ to ensure good electrical contact with the electrode.

Task 5.07 (Con't.)

9. What will happen if a electrode holder with uninsulated jaws is placed on the bench while the machine is running?

_____

10. Penetration refers to the _____ of _____ in the base metal.

UNIT 5.0 - ARC WELDING

OUTCOME-REFERENCED TESTS

Task 5.08

1. The layer of slag covering the deposited bead of a weld should be removed with:

   _____ a. sandpaper
   b. a chipping hammer
   c. a chisel
   d. heat

2. _____ is a technique used to increase the width and volume of the bead.

   _____ a. plating
   b. overlapping
   c. padding
   d. weaving

3. The (5) five variables of arc welding are?

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____

4. To restart the electrode and fill the crater and secure proper fusion, strike the arc approximately _____ in front of the crater.

   _____ a. 1/2"
   b. 3/4"
   c. 1"
   d. none of the above

5. _____ is a condition that results when the welding current is too high.

6. Penetration refers to the _____ of _____ in the base metal.

7. The length of the arc should be approximately equal to the _____ of the electrode.

8. When a weld is built up of more than one layer, it is known as a _____ pass weld.

9. The size and depth of a crater indicates the amount of _____.

TRUE-FALSE

10. _____ Electrode angle involves two positions-incline and side angles.

UNIT 5.0 - ARC WELDING

OUTCOME-REFERENCED TESTS

Task 5.09

1. The maximum width of the overall pass should not exceed more than about _____ times the rod diameter.

   _____ a. 3
   b. 4
   c. 5
   d. 6

2. _____ is a technique used to increase the width and volume of the bead.

   _____ a. plating
   b. overlapping
   c. padding
   d. weaving

3. When more than one bead is used, it is necessary to remove the _____ after each pass.

4. When a smooth finish is required on a multiple pass weld, a _____ bead is used to cover the entire area.

5. _____ or _____ is a process for building worn surfaces of shafts, wheels, and other machine parts.

6. In making a weld, when should a weaving motion be used?

   _____

7. What will determine whether a weave bead has fine or coarse ripples?

   _____

8. Does the type of weaving pattern used have any effects on the quality of a weld?

   _____

9. What is meant by padding and when is it used?

   _____

10. If a weaving motion is to be used in building up a pad, what precautions must be taken?

    _____

OUTCOME-REFERENCED TESTS

Task 5.10

1. When the thickness of the metal exceeds _____ the edges of a butt joint should be beveled.

   _____
   a. 1/16 of an inch
   b. 1/8 of an inch
   c. 1/4 of an inch
   d. 5/8 of an inch

2. The included angle of the V joint should not exceed _____ degrees.

   _____
   a. 40
   b. 50
   c. 60
   d. 90

3. Tack welds are simply short sections of weld beads _____ to _____ inches long.

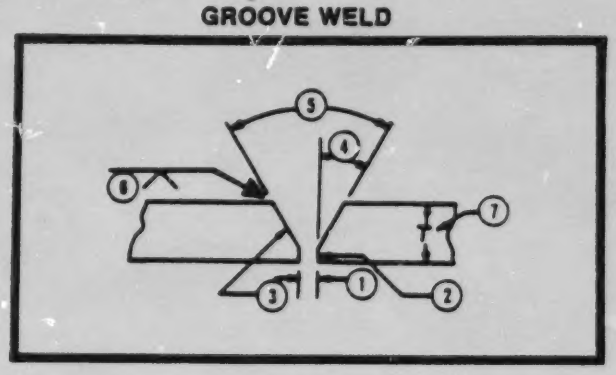
   _____
   a. 1/8 to 1/4
   b. 1/4 to 1/2
   c. 1/2 to 3/4
   d. 3/4 to 1

4. Most welding is done in the more efficient _____ position.

   _____
   a. horizontal
   b. vertical
   c. overhead
   d. flat

5. Name the terms used to identify the parts of the weld listed below:

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____
   6. _____
   7. _____



UNIT 5.0 - ARC WELDING

OUTCOME-REFERENCED TESTS

Task 5.11

1. Name (3) three of the basic welding motions used in the vertical welding.

   1. _____
   2. _____
   3. _____

2. Welding stringer beads in the vertical position, you will find it necessary to use a slightly _____ welding current and to hold a _____ arc when welding in the flat position.

3. When depositing stringer beads in a straight line, when using soap stone, it will brush off. What method is used to maintain a straight bead?

   _____

4. When welding in the vertical position, for better penetration on critical work, one would weld uphill or downhill?

   _____

TRUE-FALSE

5. _____ Welding in the vertical position, lengthing the arc gap on the upward stroke. It is normal to break the arc.

UNIT 5.0 - ARC WELDING

OUTCOME-REFERENCED TESTS

Task 5.13

1. What are some of the important factors in making a sound weld, when welding low hydrogen electrodes in the vertical position? List (4) four.

   1. _____
   2. _____
   3. _____
   4. _____

2. Name the weld used to weld a T-joint.

   _____

3. In welding a T-joint, it is important to obtain good penetration and fusion with what parts of the joint?

   _____

TRUE-FALSE

4. _____ If the arc is too long or if the angle of the electrode is incorrect, undercutting will result.

5. _____ When the fillet weld on a T-joint is tested and looks to be sound, it should peel off the plate surfaces.

Task 5.14

1. What is the included angle of the V in a single-V butt joint?

   _____

2. In the grooved joint, what is used as a guide for the width of the new pass?

   _____

3. When welding a grooved joint without a backing strip in the vertical position, it is necessary to secure complete penetration through the back side?

   _____

TRUE-FALSE

4. _____ Welding the single-V butt joint with a backing strip, it is not necessary to obtain fusion and penetration through the back side.

5. _____ The square butt joint is used in pipe welding and critical plate welding.

UNIT 5.0 - ARC WELDING

OUTCOME-REFERENCED TESTS

Task 5.16

1. The number of passes to be made on a joint depends on:

   1. _____
   2. _____
   3. _____
   4. _____

2. How is it possible to develop full strength in a corner joint?

   _____

3. To achieve complete penetration in a corner (grooved) joint form a little _____ at the leading edge of the weld crater right under the tip of the electrode.

   _____

4. When making an inside corner joint, the joint preparation is inexpensive. What makes the cost so great on heavy plate?

   _____

TRUE-FALSE

5. _____ When striking or restarting an arc, use any part of the coupon.

UNIT 5.0 - ARC WELDING

OUTCOME-REFERENCED TESTS

Task 5.17

1. Name (4) four of the various code authorities that are concerned with pipe welding.

   1. _____
   2. _____
   3. _____
   4. _____

2. What is the reason for the use of a backing ring in the welding of butt welds in pipe?

   _____

TRUE-FALSE

3. _____ The best type of electrode to use for pipe welding is the E-6012 classification.

4. _____ A welder who has been qualified on plate does not have a retest for pipe welding.

5. _____ Some electrode manufacturer's make two types of electrodes under the E-6010 classification: One that meets the general classification and another which is especially designed for pipe.

UNIT 5.0 - ARC WELDING

Answer Sheet

Task 5.01

1. b

2. d

3. a

4. In AC, the current cycles as half cycle; in DCRP and half cycle DCSP which DC current plows in one direction only.

5. Because for some welding operations the flow of current must be changed.

Task 5.02

1. 1. high top shoes
   2. cotton clothing
   3. shirts without pockets
   4. pants with no cuffs
   5. flip front welding shield
   6. gloves
   7. pliers
   8. cap to protect hair
   9. proper lens for welding
   10. striker

2. (short answer)

3. (short answer)

4. (short answer)

Task 5.03

1. 1.
   2.
   3.
   4.
   5.

2. d

3. d

4. AC

5.

Task 5.04

1. b

2. a

3. a

4. E6010 and E7018

5. pounds per square inch in thousands.

Tasks 5.05 and 5.06

1.
   1. turn machine on
   2. check polarity with rod being used
   3. check heat (high, medium, low)
   4. set fine adjustment on heat control
   5. everything else OFF

2.
   1. check shield
   2. have gloves
   3. check electrical leads
   4. machine is grounded

3. after burning each electrode

4. eye protection

5. instructor checklist and observation

Task 5.07

1. d

2. a

3. d

4. a

5. scratching

6. crackling or frying

7. short

8. clean

9. it will arc

10. depth
    fusion

Task 5.08

1. b

2. d

3. 1. correct electrode
   2. correct arc length
   3. correct current
   4. correct travel speed
   5. correct electrode angle

4. a

5. undercutting

6. depth
   fusion

7. diameter

8. multiple

9. penetration

10. true

Task 5.09

1. c

2. d

3. slag

4. weave

5. padding or surfacing

6. 1. When the width of a bead has to be increased.
   2. When the weld requires several passes.

7. The tightness of the weave motion.

8. Some weaving motions are better than others, depending on the position of the weld.

9. A process that involves putting several layers of beads on top of each other, used to build up worn surfaces.

10. Each layer must be fused in to the other; slag must be removed after each layer of beads.

Task 5.10

1. b

2. c

3. b

4. d

5. 1. root opening
   2. root face
   3. groove face
   4. bevel angle
   5. groove angle
   6. size of weld
   7. plate thickness

Task 5.11

1. 1. steady
   2. whip
   3. proper "J" to the right
   4. inverted "T"
   5. box weave
   6. "Z" weave
   7. circle

2. lower
   shorter

3. mark the lines with a center punch, make the punch indentations about 1/4 of an inch apart

4.

5. false - the arc should not be broken

Task 5.13

1. 1. use a 1/8 inch or 5/32 inch
   2. do not use a whip technique or take the electrode out of the molten pool
   3. use a small triangular weave
   4. build up a small shelf, point the electrode directly into the joint and slightly upward to permit the arc force to assist in controlling the puddle
   5. travel slow enough to maintain the shelf without causing the molten metal to spill off
   6. use currents in the lower portions of the quoted range
   7. keep the width of the weave within the confines of the bead width

Task 5.13 (Con't.)

2. fillet

3. current adjustment should be high enough to ensure good fusion and penetration to the root of the joint and to the plate surfaces

4. true

5. false - the weld should break through the throat

Task 5.14

1. 60 degrees

2. the edges or toes of the previous pass

3. one must have complete penetration to make a sound weld

4. false

5. false

Task 5.16

1. 1. joint design
   2. thickness of the plate
   3. included angle of the groove
   4. amperage setting

2. full penetration must be secured through the back side

3. hole

4. the electrode consumption is great

5. false - strike the arc only in the weld zone

Task 5.17

1. 1. ASME--The American Society of Mechanical Engineers
   2. CAPI--The American Petroluem Institute
   3. AWS --The American Welding Society
   4. --The American Water Works Association

2. Its functions are to assist the welder in securing complete penetration and fusion without burn through, to prevent spatter and slag from entering the pipe. Also prevents icicles from forming inside of the pipe.

3. false

4. false

5. true

UNIT 6.0

OPERATING GAS METAL ARC WELDING EQUIPMENT

(MIG)

GAS METAL ARC WELDING (MIG)

PREREQUISITES: None

OBJECTIVE: The objective of GMAW (MIG) welding training is to develop entry level skills for the following classification.

Welder, Gas Metal Arc (DOT 810.384-014)

The GMAW welder will be prepared to set up MIG equipment, and maintain it.

The GMAW welder will develop the manual skills necessary to produce high quality fillet and groove welds on mild steel placed in the flat, horizontal, vertical, and overhead position.

GMAW training will prepare the student to perform entry level production and maintenance welding on mild steel using the MIG process.

Criterion for evaluation of Gas Metal Arc Welding (MIG)

Recommended Text: Hobard 269

Criterion is: Weld Quality Inspection (Visual Method)

SUMMARY
SUGGESTED INSTRUCTION TIME

GAS METAL ARC WELDING UNIT/TASK		SUGGESTED HOURS
UNIT 6.0		
6.01	Introduction to GMAW Welding	3
6.02	GMAW Welding Safety	2
6.03	Set Up and Shut Down GMAW (MIG) Equipment	2
6.04	Maintain Gas Metal Arc Welding Gun (Torch)	2
6.05	Weld Stringer Beads With GMAW Equipment; Flat Position	3
6.06	Weld Carbon Steel With GMAW Equipment Butt Joint, All Positions	*
6.07	Weld Carbon Steel, T-Joints, With GMAW Equipment, Flat and Vertical Position (Up/Down)	6
6.08	GMAW Weld Pipe in Fixed Position(s), Downhill	*

*Optional

TASK LISTINGS

OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)

UNIT/TASK	DESCRIPTION
Unit 6.0	
6.01	(Introduction to GMAW Welding) Given instructions, describe the method of operation of the Gas Metal Arc Welding (GMAW) (MIG) process, type of equipment, and application of the process.
6.02	(GMAW Welding Safety) Given instructions concerning welding safety using the GMAW process, demonstrate the proper safety precautions when preparing for and using MIG welding. Meet the instructor's standards.
6.03	(Set Up and Shut Down GMAW /MIG/ Equipment) Given a GMAW (MIG) machine, 75/25 cylinder, flowmeter and materials, set up the unit for welding. After setting up the unit, shut down the unit completely meeting the instructor's specifications and standards.
6.04	(Maintain Gas Metal Arc Welding Gun /Torch/ Given GMAW equipment proper tools and supplies for maintenance, and instructions; maintain GMAW gun (torch) and wire feed system in proper operating condition. The instructor's standards must be met.
6.05	(Weld Stringer Beads With GMAW Equipment, Flat Position) Given GMAW (MIG) unit, accessories and supplies, mild steel plate, and welding specifications; weld stringer beads on flat plate. Visual inspection will show: - smooth and continuous welds - even ripple - uniform width and straight - complete fusion and uniform restarts - no porosity holes or protrusion
6.06	(Weld Carbon Steel With GMAW Equipment Butt Joint, All Positions) Given a GMAW unit, two steel plates, equipment and supplies; and specifications butt weld joints, all positions or as specified. Weld should have even ripple spacing, no undercutting on vertical member, complete crater fill at end of weld, no overlap, and leg size on fillet welds equal or close to being equal.
6.07	(Weld Carbon Steel, T-Joints, With GMAW Equipment, Flat and Vertical Position /Up/Down/ Given a GMAW unit, steel plates, and instructor's standards set up, align, and tack weld plates in the flat and vertical positions, the T-Joint configuration. Make a equal weld on one side (opposite side of tacks), and weld uphill and downhill on the other side. See standards below.

6.08 (GMAW Weld Pipe in Fixed Position(s), Downhill) Given GMAW equipment, supplies and materials, pipe, weld pipe in fixed position(s) according to specifications, downhill.

INSTRUCTOR MAY ELECT TO OMIT

UNIT	6.0	OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)
TASK	6.01	INTRODUCTION TO GMAW WELDING

PERFORMANCE OBJECTIVE:

Given instructions, describe the method of operation of the Gas Metal Arc Welding (GMAW) (MIG) process, type of equipment, and application of the process.

PERFORMANCE ACTIONS:

6.0101 Identify advantages of gas metal arc welding (GMAW or MIG) process as compared to SMAW, OAW, and GTAW welding.

6.0102 Identify/select typical equipment used for MIG welding:
a. Describe shielded gas.
b. Describe type of torch.
c. Describe electrode wire feed system.

6.0103 Describe Gas Metal Arc Welding (GMAW) process.

PERFORMANCE STANDARDS:

- Describe the method of operation of GMAW welding, the type of equipment needed, and typical applications of MIG welding.
- The instructor's standards apply and the student must demonstrate an understanding appropriate for entry level employment using the GMAW process.

SUGGESTED INSTRUCTION TIME: 3 Hours

RELATED TECHNICAL INFORMATION:

- At conclusion of MIG training, the student should be able to use or identify the related terminology with 80 percent accuracy.

GAS METAL ARC WELDING

TERMINOLOGY

GAS METAL ARC WELDING (GMAW) (MIG) - Arc welding process in which consumable base electrode is fed into weld joint at a controlled rate while a continuous blanket of inert or other gas shields the weld zone from contamination by the atmosphere.

ARC LENGTH (WELDING VOLTAGES) - Heat generated by flow of current through the gap between the end of the wire and the workpiece. Voltage appears across the gap and varies in the same direction as the length of the arc.

FERROUS - Any metal containing iron such as mild steel or stainless steel.

FLOWMETER - Device used with regulator to measure amount of gas around the arc (measuring the amount of gas coming out of the nozzle rather than the pressure of the gas). Calibrated in cubic feet per hour (cfh), the flowmeter is dependent on the regulator delivering constant outlet pressure to the flowmeter of approximately 50 psig.

GMAW WELDING CURRENT (AMPERAGE) - Usually direct current (DC) reverse polarity (RP), or DCRP, is used in MIG with the welding wire positive (+) and the work negative (-).

GUN (GMAW) - In this instruction guide, a hand held device used to transfer current and guide the electrode into the arc. It will include provisions for shielding and arc initiation.

INERT GAS - A gas which typically does not combine chemically with the base metal or filler metal. Used to create a protective atmosphere.

NON-FERROUS - Any metal that contains no iron such as aluminum or magnesium.

NOZZLE - Part of the gun used to direct shielding gas.

PULL (DRAG) (electrode) - Electrode is pointing away from direction of travel. (Pulling, backhand)

PUSH (electrode) - Electrode is pointing in direction of travel. (Pushing, forehand)

REGULATOR - Device for controlling delivery of gas at some substantially constant pressure regarding variation in the higher pressure at the source.

SHIELDING GAS - Inert or other gas(es) used to displace air around arc to prevent contamination by oxygen, nitrogen, or hydrogen from the atmosphere.

SHORT CIRCUIT TRANSFER (SHORT ARC) - GMAW process where low currents, low voltages, and small diameter wires are used to weld on thin to heavy metals, all positions.

SPATTER - Metal particles expelled during welding and which do not form a part of the weld.

SPOOL - Filler metal in a continuous length of electrode wound on cylinder.

SPRAY TRANSFER (SPRAY ARC) - GMAW process usually used with thicker metal using larger diameter wires and a shielded gas mixture of argon with 1-5 percent oxygen and done in the flat and horizontal positions only.

STICK OUT - Distance from end of electrode to contact tip of gun.

WHISKERS - Short lengths of welding wire that feed through the root gap of a grooved joint and extend out from the root of the weld in all directions.

UNIT 6.0 OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)

TASK 6.02 GMAW WELDING SAFETY

PERFORMANCE OBJECTIVE:

Given instructions concerning welding safety using the GMAW process, demonstrate the proper safety precautions when preparing for and using MIG welding. Meet the instructor's standards.

PERFORMANCE ACTIONS:

6.0201 Review safety precautions concerning:
- a. Electrical shock.
- b. ARC radiation.
- c. Air contamination.
- d. Fire and explosion.
- e. Compressed gases.
- f. Welding cleaning.
- g. Other hazards.

(NOTE: All safety precautions for ARC welding apply.)

6.0202 Lenses for helmet should be selected depending on intensity of arc.

(NOTE: Because of the clearer atmosphere around the GMAW arc, a darker shade of helmet lens must be used to reduce eye fatigue and possible eye damage. It is important that the clear cover glass, a proper filter lens, and sometimes a clear cover lens be used. Lenses should be clean. Flash goggles of approximately #2 shade should be worn under the helmet.)

6.0203 Protective clothing must be worn.

6.0204 Review safety recommendations of GMAW equipment manufacturer.

PERFORMANCE STANDARDS:

- Demonstrate safety behavior using GMAW equipment to the instructor's standards.

SUGGESTED INSTRUCTION TIME: 2 Hours

UNIT 6.0 OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)

TASK 6.03 SET UP AND SHUT DOWN GMAW (MIG) EQUIPMENT

PERFORMANCE OBJECTIVE:

Given a GMAW (MIG) machine, 75/25 cylinder, flowmeter and materials; set up the unit for welding. After setting up the unit, shut down the unit completely meeting the instructor's specifications and standards.

PERFORMANCE ACTIONS:

6.0301 Select safety equipment.

6.0302 Preliminary check for MIG welding:

a. Check that electric power controls are in OFF position.
b. Inspect to be sure hose and cable connections from gun (torch) to feeder are in good condition, properly insulated, and that connections are correctly made.
c. Be sure the nozzle is correct for the wire diameter used.
d. Inspect to be sure the wire is threaded properly through the gun.
e. Be sure the apertures of the contact tube and nozzle are clean. (Blow out the gun as necessary to dislodge dust.)
f. Check to see that the wire speed and feed have been predetermined and adjusted on the feeder control.
g. Turn on the shielded gas (and water if W.C. torch used) and adjust for desired output.
h. Be sure wire stick-out is correct.
i. Be sure contact tip is in proper shape. Replace if necessary.

6.0303 Start MIG equipment:

a. Press start switch on welding machine.
b. Place wire feeder switch on ON position.
c. Set wire feed speed control at midway point (thickness of base metal).
(NOTE: Wire speed determines welding current. Adjust speed for type of welding.)
d. Open gas cylinder valve and adjust flowmeter to recommended gas flow rate. (While opening flowmeter valve slowly, lightly squeeze gun trigger momentarily.)

UNIT 6.0 OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)

TASK 6.03 SET UP AND SHUT DOWN GMAW (MIG) EQUIPMENT (Con't.)

PERFORMANCE ACTIONS (Con't.):

e. Set voltage rehostate to recommended position for thickness of metal to be welded.
(NOTE: Voltage and wire feed must be set while welding. Suggestion: Use scrap material to set controls.)

6.0304 Stop MIG Equipment:
a. Close gas outlet valve on top of cylinder.
b. Close gas flowmeter valve.
c. Turn wire feeder to OFF position.
d. Squeeze gun trigger to bleed lines.
e. Turn off welding machine.
f. Store gun and cable assembly.

6.0305 When the welding station is shut down, all controls should be returned to zero. At the start of each project the controls will have to be adjusted for correct operations.

PERFORMANCE STANDARDS:

- Properly set up a GMAW (MIG) welding unit and shut down the equipment completely.
- Manufacturer's instruction book or specification must be met if applicable.
- Instructor's standards must be met.

SUGGESTED INSTRUCTION TIME: 2 Hours

See accompanying checklist.

MIG WELDING EQUIPMENT CHECKLIST

		CHECK
1.	All power controls are off.	( )
2.	Cable and hose connections are secure.	( )
3.	There are no visible breaks in the cable insulation.	( )
4.	The gun has the right nozzle for the diameter wire.	( )
5.	Wire is threaded correctly through the gun.	( )
6.	Nozzle is clean and free of obstructions.	( )
7.	Wire feed is set.	( )
8.	Shielded gas flow is set.	( )
9.	Water is turned on if a W.C. gun is used.	( )
10.	Wire stick-out is correct.	( )
11.	Contact tip of gun is in good shape.	( )
12.	Voltage control is set correctly.	( )
13.	Adequate ventilation is provided for welding.	( )
14.	Gloves and helmet are available.	( )
15.	Clothing for welding is suitable.	( )

Source: Giachino, Joseph W. Arc Welding, Alsip, IL: American Technical Publishers, Inc., 1977.

UNIT	6.0	OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)
TASK	6.04	MAINTAIN GAS METAL ARC WELDING GUN (TORCH)

PERFORMANCE OBJECTIVE:

Given GMAW equipment, proper tools and supplies for maintenance, and instructions; maintain GMAW gun (torch) and wire feed system in proper operating condition. The instructor's standards must be met.

PERFORMANCE ACTIONS:

6.0401 (Wire spool type station) Keep wire on spool clean. Keep spool covered except when replacing it.

6.0402 Inspect to be sure spool moves freely on shaft.

6.0403 Inspect to be sure wire does not have any sharp bends or kinks.

6.0404 Clean wire feed rollers each time a new spool of wire is installed.

6.0405 Lightly lubricate wire before wire enters rollers.

6.0406 Inspect to be sure welding cable is as straight as possible to improve wire feed.

6.0407 Inspect to be sure feed rolls are in line with each other and in line with inlet and outlet bushing.

6.0408 Be sure that the welding machine is electrically grounded. Be sure area where ground is attached is clean.

6.0409 Be sure that the ground clamp surface is clean.

6.0410 Keep the gun or torch nozzle as clean and as free from metal splatter as possible. Use creamer to remove splatter. Clean inside and outside of tube through which electrode wire passes each time electrode reel is changed.

UNIT	6.0	OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)
TASK	6.04	MAINTAIN GAS METAL ARC WELDING GUN (TORCH) (Con't.)

PERFORMANCE STANDARDS:

- Maintain GMAW welding equipment (gun or torch) in proper operating condition.
- Meet instructor's standards.
- Follow manufacturer's instruction manual.

SUGGESTED INSTRUCTION TIME: 2 Hours

RELATED TECHNICAL INFORMATION:

- Manufacturer's instruction manual.

UNIT	6.0	OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)
TASK	6.05	WELD STRINGER BEADS WITH GMAW EQUIPMENT, FLAT POSITION

PERFORMANCE OBJECTIVE:

Given GMAW (MIG) unit, accessories and supplies, mild steel plate, and welding specifications; weld stringer beads on flat plate. Visual inspection will show:

- smooth and continuous welds
- even ripple
- uniform width and straight
- complete fusion and uniform restarts
- no porosity holes or protrusion

PERFORMANCE ACTIONS:

6.0501 Select safety equipment and accessories for MIG welding.

6.0502 Draw and position plate to weld.

6.0503 Set up MIG equipment. Check equipment.

6.0504 Adjust shielding gas flow rate, voltage, and wire feed speed (amperage) (on scrap metal).

6.0505 Run stringer beads on flat plate with MIG process.

6.0506 Inspect weld(s).

PERFORMANCE STANDARDS:

- Weld stringer beads on flat mild steel plate with GMAW (MIG) equipment so that the welds are smooth and continuous, there is even ripple, uniform width and straight welds, so there is complete fusion and uniform restarts, and no porosity holes or protrusions.

SUGGESTED INSTRUCTION TIME: 3 Hours

UNIT	6.0	OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)
TASK	6.06 (Optional)	WELD CARBON STEEL WITH GMAW EQUIPMENT BUTT JOINT, ALL POSITIONS

PERFORMANCE OBJECTIVE:

Given a GMAW unit, two steel plates, equipment, supplies, and specifications; butt weld joints, all positions or as specified. Weld should have even ripple spacing, no undercutting on vertical member, complete crater fill at end of weld, no overlap, and leg size on fillet welds equal or close to being equal.

PERFORMANCE ACTIONS:

6.0601 Set up for MIG welding.

6.0602 Tack weld plates into joint position.

6.0603 Inspect position of plates; correct as necessary.

6.0604 Weld to specifications using GMAW process.

6.0605 Inspect weld quality.

PERFORMANCE STANDARDS:

- Make butt joint welds on carbon steel with GMAW equipment, all positions specified by instructor.
- Visual inspection of weld should show. Even ripple spacing, no undercutting, complete crater fill at end of weld, no overlap, leg size on fillet welds equal or close to being equal.

SUGGESTED INSTRUCTION TIME: Optional

UNIT	6.0	OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)
TASK	6.07	WELD CARBON STEEL, T-JOINTS, WITH GMAW EQUIPMENT, FLAT AND VERTICAL POSITION (UP/DOWN)

PERFORMANCE OBJECTIVE:

Given a GMAW unit, steel plates, and instructor's standards set-up, align, and tack weld plates in the flat and vertical positions and the T-Joint configuration. Make a equal leg fillet weld on one side (opposite side of tacks), and weld uphill and downhill on the other side.

PERFORMANCE ACTIONS:

6.0701 Select safety equipment.

6.0702 Select hand tools.

6.0703 Set up power supply.

6.0704 Check to see if nozzle on gun is clean (spray with antispatter if necessary).

6.0705 Adjust shielded gas flow rate.

6.0706 Set voltage and wire feed speed (amperage) (using scrap metal).

6.0707 Tack plates to specifications.

6.0708 Place T-Joint flat on table.

6.0709 Weld as specifications, uphill and downhill.

PERFORMANCE STANDARDS:

- Make fillet welds in the flat and vertical positions using GMAW equipment, up and down.
- A visual inspection of welds should show:
  - even ripple spacing
  - no undercutting on vertical member
  - complete crater fill at end of weld
  - no overlap
  - leg size on fillet welds equal or close to being equal

SUGGESTED INSTRUCTION TIME: 6 Hours

UNIT	6.0	OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)
TASK	6.08 (Optional)	GMAW WELD PIPE IN FIXED POSITION(S), DOWNHILL

PERFORMANCE OBJECTIVE:

Given GMAW equipment, supplies and materials, pipe, weld pipe in fixed position(s) according to specifications, downhill.

INSTRUCTOR MAY ELECT TO OMIT

PERFORMANCE ACTIONS:

6.0801 Select safety equipment.

6.0802 Draw mild steel pipe from instructor.

6.0803 Prepare pipe joints as necessary.

6.0804 Position pipe for joint desired.

6.0805 Set up MIG machine, adjust for welding job.

6.0806 Tack weld pipe into joint position.

6.0807 Inspect position of pipe; correct as necessary.

6.0808 Weld pipe to specifications using GMAW process.

6.0809 Inspect weld quality, especially for slag inclusions. (Weld should pass bend test without cracking.)

PERFORMANCE STANDARDS:

- Weld given pipe in specified fixed position(s) downhill.
- Weld should have even ripple spacing, no undercutting, complete crater fill at end of weld, no overlap, and leg size should be close to equal. Slag inclusions should not be evident.

SUGGESTED INSTRUCTION TIME: Optional

CHECKLIST

GMAW (MIG) WELDING

(Check to indicate student has mastered weld to industry standards; if otherwise, omit mark.)

	POSITIONS AND JOINTS-MILD STEEL																				
	Flat					Horizontal					Vertical				Overhead				Pipe	
	Stringer	Butt	T	Lap	Corner	Stringer	Butt	T	Lap	Corner	Butt	T	Lap	Corner	Butt	T	Lap	Corner	Pipe Downhill	
1. Bead widths are right size.																				
2. Beads have uniform ripples.																				
3. Weld beads not too flat (proper width).																				
4. Weld beads not too high (proper width).																				
5. Weld penetration is sufficient.																				
6. No cold laps on surface.																				
7. No surface porosity on welds.																				
8. No subsurface porosity.																				
9. No crater cracks.																				
10. No burn thru.																				
11. End crater is filled.																				
12. Weld passed bend test without cracking.																				

UNIT 6.0 - MIG WELDING

OUTCOME-REFERENCED TESTS

1. Identify which welding process uses a continuous consumable wire electrode.

___ a. mig
b. oxyacetylene
c. tig
d. carbon arc

2. Identify the most efficient polarity used in mig welding.

___ a. DCSP
b. DCRP
c. ACHF
d. ACRP

3. Which wire listed below is best for mig welding low carbon steels.

___ a. ER-309
b. E-70S-3
c. E-70S-6
d. ER-1100

4. Identify the shielding gas mixtures used in the short ARC mig welding.

___ a. 25 percent He and 75 percent argon
b. 25 percent carbon dioxide, 75 percent argon
c. 25 percent oxygen and 75 percent argon
d. 25 percent argon and 75 percent He

5. Indicate the proper type of anti-splatter compound used in mig gun noggles to eliminate splatter.

___ a. water
b. grease
c. flux
d. tip dip or spray anti-splatter

6. List three things that will cause improper gas coverage during mig welding.

1. _____
2. _____
3. _____

7. List the two types of mig welding guns.

1. _____
2. _____

8. List eight items that must be checked before beginning to mig weld.

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____
   6. _____
   7. _____
   8. _____

9. List the gas mixture used in short arc mig welding.

   _____

10. List at least three items that should be checked before operating the mig machine.

    1. _____
    2. _____
    3. _____

11. Explain what excessive voltage will cause in mig welding.

    _____

12. Explain what will happen if the nozzle of the mig gun is filled with metal particles.

    _____

13. Explain what will happen if the filler wire develops a kink in it while mig welding.

    _____

14. Explain why the spools of mig wire should remain covered while in use.

    _____

DEMONSTRATION

15. Given a display or list of safety equipment, select the proper equipment to be used for mig welding.

16. After a lecture and demonstration of the mig gas, demonstrate the proper settings of gas flow, voltage, and wire feed on scrap steel.

17. Given a piece of plate and mig machine, demonstrate a flat head without cold lap, undercut, or porosity to satisfy the instructor.

18. Given two pieces of schedule 40 (4 inch) c/s pipe with a 60 degree included bevel and a mig machine, demonstrate a root pass run with the downhill process with an uphill filler and cover.

19. Given two pieces of schedule 40 (4 inch) c/s pipe, fit and align for tack and weld out procedures.

Unit 6.0 - Mig Welding

Answer Sheet

1. a

2. b

3. b

4. b

5. d

6. 1. no gas
   2. water in gas cylinder
   3. holding gun too far away from weld

7. 1. air
   2. water cooled

8. 1. check that electric power controls are in OFF position
   2. inspect to be sure hose and cable connections from gun (torch) to feeder are in good condition, properly insulated, and that connections are correctly made
   3. be sure the nozzle is correct for the wire diameter used
   4. inspect to be sure the wire is threaded properly through the gun
   5. be sure the apertures of the contact tube an nozzle are clean
   6. check to see that the wire speed and feed have been predetermined and adjusted on the feeder control
   7. turn on the shielded gas (and water in W.C. torch used) and adjust for desired output
   8. be sure wire stick-out is correct

9. 25 percent carbon dioxide and 75 percent argon

10. 1. proper sound
    2. amp/volt setting to correspond with wire size and metal thickness
    3. cover over the spool of wire

11. it will enlarge the puddle increasing the inductance which will cause the weld to crack or break in half

12. it will stop the flow of gas from protecting the puddle from oxidation

13. it will jam in the contact tip, coax cable, or infeed rollers

14. To ensure that clean wire will enter the cable and mig gas. Dirt will collect inside the cable and restrict the wire speed.

UNIT 7.0

GAS TUNGSTEN ARC WELDING (GTAW)
(TIG)

GAS TUNGSTEN ARC WELDING (GTAW)
(TIG)

PREREQUISITES: Oxyacetylene welding is recommended as a prerequisite for the purpose of developing two handed introductory skills.

OBJECTIVES: The objective for Gas Tungsten Arc Welding (GTAW) is to develop entry level skills for: Welder, Gas Tungsten Arc (DOT 810.384-014)

The graduate of TIG welding training is prepared to identify GTAW welding equipment, accessories, and supplies; set up TIG equipment, adjust equipment, and manipulate the welding torch; start the arc and run straight beads with TIG equipment; and weld with the GTAW process in all positions (flat, horizontal, vertical, and overhead.

The GTAW welder will be prepared to perform entry level production and maintenance welding on both light and heavy gage ferrous and non-ferrous metals.

SUMMARY

SUGGESTED INSTRUCTION TIME

GAS TUNGSTEN ARC WELDING UNIT/TASK		SUGGESTED HOURS
Unit 7.0		
7.01	Introduction to (GTAW) Welding	3
7.02	(GTAW) Safety	2
7.03	Prepare for GTAW Welding, Startup Equipment, Adjust, Shut-down	1
7.04	Disassemble and Clean GTAW (TIG) Torch Assembly	1
7.05	Carrying the Puddle	4-6
7.06	Weld Stringer Beads, Mild Steel, and Flat Position, Using GTAW Equipment	2
7.07	Weld Carbon Steel With GTAW (TIG) Equipment, All Positions	20-30
7.08	Weld Stainless Steels With GTAW (TIG) Process, All Positions	*
7.09	Weld Aluminum or Aluminum Alloys With GTAW (TIG) Equipment, Flat. T and Open Butt	40-50

*Optional

TASK LISTINGS

GAS TUNGSTEN ARC WELDING (GTAW)

UNIT/TASK	DESCRIPTION
Unit 7.0	
7.01	(Introduction To /GTAW/ Welding) Given instructions, describe the method of operation of gas tungsten arc welding (GTAW) (TIG), type of equipment, and application of the gas tungsten arc welding (TIG) process.
7.02	(GTAW Safety) Given instructions concerning welding safety using the GTAW process, demonstrate the proper safety precautions when preparing for and using TIG welding.
7.03	(Prepare for GTAW Welding, Startup, Equipment, Adjust, Shut-down) Given instructions, GTAW (TIG) machine, equipment, tools, and supplies; set-up, adjust, and shut-down gas tungsten arc welding equipment by a standard set of procedural steps.
7.04	(Disassemble and Clean GTAW /TIG/ Torch Assembly) Given a complete GTAW (TIG) unit, necessary tools and accessories, appropriate manual and exploded view; remove, disassemble, reassemble and replace torch assembly in accordance with and in the sequence listed in the work order.
7.05	(Carrying the Puddle) Given GTAW welding equipment and metal to weld without filler rod, establish a molten puddle and run straight even beads (without filler) in the flat or other positions assigned by the instructor.
7.06	(Weld Stringer Beads, Mild Steel, and Flat Position, Using GTAW Equipment) Given a GTAW unit, equipment, steel plate(s), filler rod and tungsten electrode; weld stringer beads on mild steel provided in the flat position.
7.07	(Weld Carbon Steel With GTAW /TIG/ Equipment, All Positions) Given a GTAW (TIG) unit and necessary supplies, carbon steel alloy metal, tungsten electrode, and filler rod, and a welding job; weld the carbon steel alloy joints using fillet and groove welds following specifications given (all positions). The finished weld should be smooth and continuous, show complete penetration, have no fusion between the weld bead and base metal, and have no cracks, undercutting, or overlap.

7.08 (Weld Stainless Steels With GTAW /TIG/ Process, All Positions) Given GTAW (TIG) welding equipment, tungsten electrode and filler rod, stainless alloy steels, and specifications; weld stainless steel joints using fillet and groove welds so that the joints have smooth and continuous welds, complete penetration, fusion between the weld bead and base metal, and no cracks, undercutting, ot overlapping. All positions.

7.09 (Weld Aluminum or Aluminum Alloys With GTAW /TIG/ Equipment, Flat, T, and Open Butt positions) Given GTAW (TIG) equipment, tungsten electrode and filler rod, aluminum or aluminum alloy material, and job specifications; weld aluminum joints using fillet and groove welds, Flat, T, and Open Butt positions. The finished welds should be smooth and continuous, show complete penetration, have complete fusion between weld bead and base metal, and have no cracks, undercutting, or overlap. The complete job must meet the specifications given.

UNIT 7.0 GAS TUNGSTEN ARC WELDING (GTAW)

TASK 7.01 INTRODUCTION TO (GTAW) WELDING

PERFORMANCE OBJECTIVE:

Given instructions, describe the method of operation of gas tungsten arc welding (GTAW) (TIG), type of equipment, and application of the gas tungsten arc welding (TIG) process.

PERFORMANCE ACTIONS:

7.0101 Identify the advantages of the gas tungsten arc welding (GTAW) process as compared to SMAW, OAW, and GMAW welding processes.

7.0102 Identify/select typical equipment used for (TIG) welding:
a. Describe the shielded gas: Inert gas.
b. Describe the difference air and water cooled torches.
c. Describe the tungsten electrodes.

7.0103 Describe gas tungsten arc welding (GTAW) process.

PERFORMANCE STANDARDS:

- Describe the method of operation of GTAW welding, the type of equipment used, and typical applications of the Tig welding process.
- The instructor's standards apply and the student must demonstrate an understanding appropriate for entry level employment using the GTAW process.

SUGGESTED INSTRUCTION TIME: 3 Hours

UNIT 7.0 GAS TUNGSTEN ARC WELDING (GTAW)

TASK 7.02 (GTAW) SAFETY

PERFORMANCE OBJECTIVE:

Given instructions concerning welding safety using the GTAW process, demonstrate the proper safety precautions when preparing for and using TIG welding.

PERFORMANCE ACTIONS:

7.0201 Review safety precautions concerning:
- a. Electrical shock.
- b. ARC radiation.
- c. Air contamination.
- d. Fire and explosion.
- e. Compressed gases.
- f. Welding cleaning.
- g. Other hazards.

(NOTE: All safety precautions for ARC welding apply.)

7.0202 Lenses for helmet should be selected depending on intensity of the arc.

7.0203 Protective clothing such as an apron and gloves must be used when welding with gas tungsten arc.

7.0204 Review safety recommendations of GTAW equipment manufacturer.

PERFORMANCE STANDARDS:

- Demonstrate safety behavior using GTAW equipment to the instructor's standards.

SUGGESTED INSTRUCTION TIME: 2 Hours

UNIT 7.0 GAS TUNGSTEN ARC WELDING (GTAW)

TASK 7.03 PREPARE FOR GTAW WELDING, STARTUP EQUIPMENT, ADJUST, SHUT-DOWN

PERFORMANCE OBJECTIVE:

Given instructions, GTAW (TIG) machine, equipment, tools, and supplies; set up, adjust, and shut-down gas tungsten arc welding equipment by a standard set of procedural steps.

PERFORMANCE ACTIONS:

7.0301 Review standard procedures for GTAW (TIG) startup.

7.0302 Select equipment: Safety equipment, wire brush, and pliers.

7.0303 Set up, adjust, and shut-down GTAW machine for:

a. DCSP--welding stainless steel or mild steel (most metals).
DCRP--aluminum and magnesium (occasional use, ACHF preferred).

b. ACHF--welding aluminum or magnesium (or other metals).

(NOTE: Observe proper procedures for preparing electrode and torch for DC and AC. Make proper equipment adjustments for AC and DC operation.

Procedural steps as established by Hobart School of Welding or similar standards apply to equipment start up and adjustment (See Gas Tungsten ARC Welding, Troy, OH: Hobart School of Welding Technology, pp. 9-11).

Typical Steps

(1) Assemble and inspect TIG equipment.
   (a) Check gas supply lines for leaks.
   (b) Select proper nozzel and electrode.
   (c) Check all leads.
(2) Open gas cylinder valve and adjust for proper flow.
(3) Check water supply if W.C. torch is being used.
(4) Adjust machine range for weld to be made (current).
(5) Switch machine on.
(6) Shut-down machine by procedural steps.

UNIT	7.0	GAS TUNGSTEN ARC WELDING (GTAW)
TASK	7.03	PREPARE FOR GTAW WELDING, STARTUP EQUIPMENT, ADJUST, SHUT-DOWN (Con't.)

PERFORMANCE ACTIONS (Con't.):

7.0304 Prepare electrode as necessary.

(NOTE: See addendum page for standards.)

PERFORMANCE STANDARDS:

- Set-up, adjust, and shut-down gas tungsten arc welding machine and equipment according to standard procedures established by the instructor (see reference publication for suggested standards).
- Cylinder must be secured.
- Weld control in proper position.
- Polarity switch for DC as appropriate.
- Water and inert gas turned on.
- Bleed gas line and shut down equipment completely.

SUGGESTED INSTRUCTION TIME: 1 Hour

RELATED TECHNICAL INFORMATION:

- Prepare tungsten and place in torch, adjust for proper electrode stickout.
- Prepare DC or AC electrodes.
- Adjust shielded gas flow rate, cubic feet hour (CFH).

TIG WELDING EQUIPMENT CHECKLIST

		CHECK
1.	All cable connections are tight.	( )
2.	Machine is properly grounded.	( )
3.	Power disconnect switch is turned on for welding.	( )
4.	Holder is equipped with the proper diameter electrode and gas cup.	( )
5.	Electrode projects the right distance beyond the end of the gas cup.	( )
6.	Electrode is firmly held in the collet.	( )
7.	Machine is set for correct polarity.	( )
8.	Machine is set for correct welding amperage.	( )
9.	Regulator is set for correct gas flow.	( )
10.	If W.C. torch is used, water is turned on.	( )
11.	Helmet has clear lenses of right shade.	( )
12.	Gloves are available; protective clothing is suitable for welding.	( )

Source: Giachino, Joseph W. Arc Welding, Alisp, IL: American Technical Publishers, Inc., 1977.

UNIT	7.0	GAS TUNGSTEN ARC WELDING (GTAW)
TASK	7.04	DISASSEMBLE AND CLEAN GTAW (TIG) TORCH ASSEMBLY

PERFORMANCE OBJECTIVE:

Given a complete GTAW (TIG) unit, necessary tools and accessories, appropriate manual and exploded view; remove, disassemble, reassemble and replace torch assembly in accordance with and in the sequence listed in the work order.

PERFORMANCE ACTIONS:

7.0401 Check that electrical power, water, (if applicable) and shielded gas are shut off.

7.0402 Assemble tools and supplies.

7.0403 Remove torch assembly from GTAW (TIG) power source, water source, and gas source.

7.0404 Disassemble torch.

7.0405 Inspect component parts.

7.0406 Replace defective parts.

7.0407 Reassemble torch assembly.

7.0408 Connect torch assembly to power source, water source, and gas source.

7.0409 Test reassembled torch for leaks and correct operation.

PERFORMANCE STANDARDS:

- Remove, disassemble, reassemble, and replace a GTAW (TIG) torch assembly to manufacturer's instructions and specifications meeting instructor's standard. The TIG torch assembly must be operational upon assembly without any damage.

SUGGESTED INSTRUCTION TIME: 1 Hour

UNIT 7.0 GAS TUNGSTEN ARC WELDING (GTAW)

TASK 7.05 CARRYING THE PUDDLE

PERFORMANCE OBJECTIVE:

Given GTAW welding equipment and metal to weld without filler rod, establish a molten puddle and run straight even beads (without filler) in the flat or other positions assigned by the instructor.

PERFORMANCE ACTIONS:

7.0501 Put on safety equipment.

7.0502 Position steel on support (table, etc.) as instructed and to the satisfaction of the instructor.

7.0503 Set up TIG welding station and adjust flowmeter.

7.0504 Turn on ARC welding machine and adjust for proper current.

7.0505 Point torch in direction of weld at 75/25 degree angle with no side.

7.0506 Touch torch to plate to start the arc; then, withdraw the electrode so it is about 1/8 inch above metal.

7.0507 Move arc in small circle until pool of molten metal form (about 1/4 inch in diameter).

7.0508 Move torch along line of intended weld to form overlapping circles (carry the puddle) in uniform bead. (Scribe a line or use a straight edge to help puddle a straight bead.)

(NOTE: Practice will be required to develop skill in puddling.)

PERFORMANCE STANDARDS:

- Run a bead without filler rod, according to the instructor's standards, keeping the bead straight and maintaining a uniform puddle.

SUGGESTED INSTRUCTION TIME: 4-6 Hours

RELATED TECHNICAL INFORMATION:

- Safety procedures.
- Setting up oxy-fuel station.
- Flame adjustment.

Unit	7.0	GAS TUNGSTEN ARC WELDING (GTAW)
TASK	7.06	WELD STRINGER BEADS, MILD STEEL, AND FLAT POSITION, USING GTAW EQUIPMENT

PERFORMANCE OBJECTIVE:

Given a GTAW unit, equipment, steel plate(s), filler rod and tungsten electrode; weld stringer beads on mild steel provided in the flat position.

PERFORMANCE ACTIONS:

7.0601 Set machine:
- a. DC Electrode negative (straight polarity).
- b. Amperage.
- c. Hot Start.
- d. Gas flow rate.
- e. Tungsten electrode stickout.
- f. Other settings as appropriate.

7.0602 Place mild steel to be welded in flat position.

7.0603 Run straight beads using TIG welding process. (Adjust current setting to deposit uniform beads.)

PERFORMANCE STANDARDS:

- Run stringer beads using TIG welding process.
- The metal must be clean. Proper tungsten must be selected and properly prepared. Welds must be of uniform width with even ripple and penetration.
- The instructor's standards applies.

SUGGESTED INSTRUCTION TIME: 2 Hours

UNIT	7.0	GAS TUNGSTEN ARC WELDING (GTAW)
TASK	7.07	WELD CARBON STEEL WITH GTAW (TIG) EQUIPMENT, ALL POSITIONS

PERFORMANCE OBJECTIVE:

Given a GTAW (TIG) unit and necessary supplies, carbon steel alloy metal, tungsten electrode, and filler rod, and a welding job; weld the carbon steel alloy joints using fillet and groove welds following specifications given (all positions). The finished weld should be smooth and continuous, show complete penetration, have no fusion between the weld bead and base metal, and have no cracks, undercutting, or overlap.

PERFORMANCE ACTIONS:

7.0701 Select safety equipment.

7.0702 Set up equipment.

7.0703 Position cables and hoses so they will not be damaged.

7.0704 Turn on electrical equipment.

7.0705 Turn on check waterflow, as required.

7.0706 Turn on and adjust shielded gas.

7.0707 Adjust current.

7.0708 Weld joints using fillet and groove welds in all positions according to job specifications.

PERFORMANCE STANDARDS:

- Weld carbon steel alloy joints, T and Open Butt to job specifications using a GTAW (TIG) unit.
- Weld should be free of undercut and overlap. There should be no porosity or cracks. Typically, the weld should be stronger than the base metal.

SUGGESTED INSTRUCTION TIME: 20-30 Hours

RELATED TECHNICAL INFORMATION:

- Recommended that the student gain proficiency in welding in the flat, vertical, and overhead positions.

UNIT	7.0	GAS TUNGSTEN ARC WELDING (GTAW)
TASK	7.08 (Optional)	WELD STAINLESS STEELS WITH GTAW (TIG) PROCESS, ALL POSITIONS

PERFORMANCE OBJECTIVE:

Given GTAW (TIG) welding equipment, tungsten electrode and filler rod, stainless alloy steels, and specifications; weld stainless steel joints using fillet and groove welds so that the joints have smooth and continuous welds, complete penetration, fusion between the weld bead and base metal, and no cracks, undercutting, or overlapping. All positions.

PERFORMANCE ACTIONS:

7.0801 Select safety equipment.

7.0802 Set up equipment.

7.0803 Position all cables and hoses so they may not be burned or damaged.

7.0804 Turn on electrical equipment.

(NOTE: Typically amperage setting is slightly less than with mild steel welding.)

7.0805 Turn on and check water flow, as required.

7.0806 Turn on and adjust shielded gas.

7.0807 Adjust current.

7.0808 Weld joints using fillet and groove welds in all positions according to job specifications.

PERFORMANCE STANDARDS:

- Weld stainless steel alloy joints to job specifications using the GTAW (TIG) process. All positions.
- Joints should be carefully prepared. Overheating of stainless steel should be avoided. Preventative measures should be taken to reduce oxidation on open root welds.

SUGGESTED INSTRUCTION TIME: Optional (Depends on the availability of stainless steel and budget constraints.)

UNIT	7.0	GAS TUNGSTEN ARC WELDING (GTAW)
TASK	7.08	WELD STAINLESS STEELS WITH GTAW (TIG) PROCESS, ALL POSITIONS (Con't.)

RELATED TECHNICAL INFORMATION:

- Match proper filler metal to base metal.
- Identify contamination sources of stainless steel.
- Manufacturer's data on stainless steel product to be welded.
- Characteristics of stainless steel.

UNIT	7.0	GAS TUNGSTEN ARC WELDING (GTAW)
TASK	7.09	WELD ALUMINUM OR ALUMINUM ALLOYS WITH GTAW (TIG) EQUIPMENT, FLAT, T, AND OPEN BUTT

PERFORMANCE OBJECTIVE:

Given GTAW (TIG) equipment, tungsten electrode and filler rod, aluminum or aluminum alloy material, and job specifications; weld aluminum joints using fillet and groove welds, Flat, T, and Open Butt. The finished welds should be smooth and continuous, show complete penetration, have complete fusion between weld bead and base metal, and have no cracks, undercutting, or overlap. The complete job must meet the specifications given.

PERFORMANCE ACTIONS:

7.0901 Select safety equipment.

7.0902 Set up equipment.

7.0903 Position cables and hoses so they cannot be burned or damaged.

7.0904 Turn on electrical equipment, (AC-HF).

7.0905 Turn on and check water flow, as required.

7.0906 Turn on and adjust shielding gas.

7.0907 Adjust current.

7.0908 Weld joints using fillet and groove welds, all positions, according to job specifications.

PERFORMANCE STANDARDS:

- Weld aluminum joints to job specifications using GTAW process.
- Prior to welding, clean aluminum surface of oxide and weld immediately after oxide removal (within 8 hours).
- The aluminum weld should have a smooth, regular face with an even ripple.
- A white line should appear along each side of the weld indicating the oxide has been cleaned by the arc.
- Aluminum filler metal should be selected based on the application of the weldment and should meet the instructor's standards.

UNIT	7.0	GAS TUNGSTEN ARC WELDING (GTAW)
TASK	7.09	WELD ALUMINUM OR ALUMINUM ALLOYS WITH GTAW (TIG) EQUIPMENT, ALL POSITIONS

SUGGESTED INSTRUCTION TIME: 40-50 Hours (Provided there is an adequate budget for required expendibles such as aluminum base metal and welding rods.)

RELATED TECHNICAL INFORMATION:

- Welding characteristics of aluminum.
- Aluminum weld quality.

ADDITIONAL TIG TRAINING

At the discretion of the instructor, GTAW (TIG) training might include additional tasks.

For the student who qualifies for additional individualized training in GTAW (TIG) welding, a workbook such as Gas Tungsten Arc Welding, Troy, OH: Hobart School of Welding Technology, 1979, may be used as a self-paced, performance-based instruction aid, or instructor developed materials may be used.

CHECKLIST

GTAW (TIG) WELDING

POSITIONS AND JOINTS-MILD STEEL
(Check if performance is satisfactory to industry standards.)

	Flat					Horizontal				Vertical				Overhead			
	Straight Bead	Butt	T	Lap	Corner	Butt	T	Lap	Corner	Butt	T	Lap	Corner	Butt	T	Lap	Corner
1. Bead widths are right size.																	
2. Beads have uniform ripples.																	
3. Weld beads not too flat.																	
4. Weld Beads not too high.																	
5. Weld penetration is sufficient.																	
6. No cold laps on surface.																	
7. No surface porosity.																	
8. No subsurface porosity.																	
9. No crater cracks.																	
10. No burn thru.																	
11. End crater is filled.																	
12. Weld passed bend test without cracking.																	

INDICATED METAL WELDED
(Check if performace is satisfactory to industry standards.)

Mild Steel																		
Aluminum																		
Stainless Steel																		
Other																		

*Emphasis should be placed on horizontal and vertical positions.

UNIT 7.0 - TIG WELDING

OUTCOME-REFERENCED TEST

1. How should the tungsten be grounded when welding alloy steel?

   _____

2. Why should gas tungsten arc welding be preformed away from outside air flow?

   _____

3. What type of current is used for GTAW of stainless and alloy steels?

   _____

4. How should the tungsten be grounded?

   _____

5. What color tip tungsten is used for welding aluminum?

   _____

6. What is the purpose of the welder positioning all the hoses and cables before starting to weld?

   _____

7. What grade of tungsten is recommended for welding aluminum?

   _____

COMPLETION

8. A number 10 lens provides the welder eye protection up to _____ amps.

9. An electrical shock is very likely if the welder is working in a very _____ area.

10. A _____ torch is mandatory when welding on large aluminum casting.

11. _____ will be required to develop skill in reading and carrying the puddle.

12. Porosity in "TIG" welding is mainly due to the welder's _____ and _____.

13. Overheating of stainless steels can cause severe _____.

Unit 7.0 - Tig Welding (Con't.)

14. All metals being "TIG" welded must be free from _____ and _____.

15. Tungsten regardless of purity is a _____ electrode.

TRUE-FALSE

16. _____ The same safety standards apply to GTAW as apply to SMAW.

17. _____ Contamination is one of the disadvantages of GTAW.

18. _____ Preheating is required on most heavy casting, whether cast iron or aluminum.

19. _____ Regardless how experienced the welder may be, a check-off list should be followed in setting up a welding rig to GTAW.

20. _____ The only source of contamination in GTAW results from the tungsten touching the base metal.

21. _____ Cotton clothing will deteriorate when exposed to the lights and rays from the arc weld.

22. _____ ACHF is not an absolute must in welding aluminum.

23. _____ All welding machines must have an external power disconnect switch.

24. _____ Current adjustment are much higher for mild steel than for alloy steels.

25. _____ A properly fitted joint is not always necessary as the welder will do this before he welds the joint.

26. _____ Subsurface porosity is the result of the welder starting his arc in the weld zone.

Unit 7.0 - TIG WELDING

Answer Sheet

1. a fine point
2. contamination
3. DCSP
4. blount end
5. green tipped
6. so they won't get damaged
7. pure tungsten
8.
9. damp
10. water cooled
11. practice
12. starts and stops
13. warpage
14. oil and grease
15. non-consumable
16. true
17.
18.
19. true
20.
21. false
22.
23.
24. false
25. false
26. true

UNIT 8.0

WELD TESTING

SUMMARY

SUGGESTED INSTRUCTION TIME

WELD TESTING UNIT/TASK		SUGGESTED HOURS
Unit 8.0		
8.01	Make Guided Bend Test of Butt Joint (Option)	*
8.02	Test Fillet Welded Joint	*
8.03	Conduct Visual Inspection of Weld	*

*Optional

TASK LISTINGS

WELD TESTING

UNIT/TASK	DESCRIPTION
Unit 8.0	
8.01	(Make Guided Bend Test of Butt Joint /Optional/) Given equipment to make guided bend test, bend test the weld of a butt joint. Examine convex surface of specimen for cracks or other discontinuities. Cracks or open discontinuity exceeding 1/8 inch measured in any direction after bend test will be evidence of the weld failing. Cracks occurring on corners of specimen during testing are not considered. (NOTE: This is an orientation task and depends on the availability of appropriate equipment.)
8.02	(Test Fillet Welded Joint /Optional/) Given equipment to make test, test specimen, rupture a fillet welded joint to force meeting the instructor's standards in procedures and weld test. (NOTE: This is an orientation task and depends on the availability of appropriate equipment.)
8.03	(Conduct Visual Inspection of Weld) Given such aids as a pocket magnifier, a flashlight, a borescope, mirror, a weld gauge, straight edge, a T square, and weld standards, and experiences and instruction; conduct a visual quality control inspection of welds.

UNIT 8.0 WELD TESTING

TASK 8.01 (Optional) MAKE GUIDED BEND TEST OF BUTT JOINT (OPTIONAL)

PERFORMANCE OBJECTIVE:

Given equipment to make guided bend test, bend test the weld of a butt joint. Examine convex surface of specimen for cracks or other discontinuities. Cracks or open discontinuity exceeding 1/8 inch measured in any direction after bend test will be evidence of the weld failing. Cracks occurring on corners of specimen during testing are not considered.

(NOTE: This is an orientation task and depends on the availability of appropriate equipment.)

PERFORMANCE ACTIONS:

8.0101 Obtain welded metal for bend test.

8.0102 Make visual inspection of weld. Weld should be acceptable based on following standards:

a. No cracks.
b. No evidence of incomplete joint penetration, otherwise it will be considered as failing test.
c. Complete fusion between weld metal and base metal.
d. Porosity does not exceed 1/16 inch maximum and has no more than a combined total of 1/8 inch in any one square inch of weld.
e. Undercut must not exceed 1/32 inch wide, 1/32 inch deep, and have no more than the combined total of 2 inches of undercut in any 6 inches of weld.
f. Face and root reinforcement should not exceed the specified dimensions and must show a gradual transition to the surface of the base metal. Reinforcement must blend smoothly into transition areas free from edge weld undercut.
g. Root reinforcement shall be flush with surface of base metal minimum to 1/16 inch maximum.
h. Face reinforcement shall be flush with the surface of base metal minimum to 1/8 inch maximum.

8.0103 Prepare bend test samples:

a. Scribe welder identification on test samples (sections).
b. Flame-cut workpiece into 4 parallel sections to expose weld area.

UNIT	8.0	WELD TESTING
TASK	8.01 (Optional)	MAKE GUIDED BEND TEST OF BUTT JOINT (OPTIONAL) (Con't.)

PERFORMANCE ACTIONS (Con't.):

c. Grind both surfaces of weld flush with plate on two test samples. Do not remove base metal.

8.0104 Bend each strip in a guided bend jig. (Or by equivalent method.)

a. Bend one test strip root side up.

b. Bend one test strip face side up.

PERFORMANCE STANDARDS:

- Bend test butt joint.
- Convex surface of specimen shall be examined for cracks or other open discontinuities.
- Cracks or open discontinuity exceeding 1/8 inch measured in any direction after test will be evidence of the weld failing.
- Cracks occurring on the corners of the specimen during testing shall not be considered.

SUGGESTED INSTRUCTION TIME: Optional

RELATED TECHNICAL INFORMATION:

"Acceptance Criteria - Bend Tests"

"The weld and heat affected zone of transverse-weld bend specimen shall be completely within the bend portion of the specimen after testing.

The guided-bend specimen shall have no open defects exceeding 1/8 inch (1/16 inch for corrosion resistance weld overlay cladding) measured in a direction on the convex surface of the specimen after bending, except that cracks occurring on the corners of the specimen during testing shall not be considered unless there is definite evidence that they result from slag inclusions or other internal defects."

UNIT 8.0 WELD TESTING

TASK 8.02 (Optional) TEST FILLET WELDED JOINT

PERFORMANCE OBJECTIVE:

Given equipment to make test, test specimen, rupture a fillet welded joint by force meeting the instructor's standards in procedures and weld test.

PERFORMANCE ACTIONS:

8.0201 Assemble supplies, equipment for testing fillet weld.

8.0202 Prepare specimen to instructor's or text standards. (Position specimen for rupturing fillet weld.)

8.0203 Apply force to welded specimen until a break in the specimen occurs.

8.0204 Check the fractured weld for soundness. (In addition, the weld may be etched and examined for cracks if the etch test is included in instruction/orientation.)

PERFORMANCE STANDARDS:

- Test fillet weld joint by rupturing the joint by force.
- Process and weld test must satisfy instructor's standards.

SUGGESTED INSTRUCTION TIME: Optional

UNIT	8.03	WELD TESTING
TASK	8.03	CONDUCT VISUAL INSPECTION OF WELD

PERFORMANCE OBJECTIVE:

Given such aids as a pocket magnifier, a flashlight a borescope, mirror, a weld gauge, straight edge, a T square, and weld standards, and experiences and instruction; conduct a visual quality control inspection of welds.

PERFORMANCE ACTIONS:

8.0301 Check basic materials, joint penetration, proper welding procedures and proper sequence of performance steps (welding process manipulation and technique.)

8.0302 Note errors in weld preparation, dimensions, alignment, fit-up, cleanliness, welding procedures, warpage, finish, and mishandling in marking.

8.0303 Look for scabs, seams, scale, surface slag, laminations, roughness, spatter, craters, surface porosity, undercuts, overlaps, cracks, and inadequate penetration.

(NOTE: 1. To conduct the visual inspection, the student must know welding more thoroughly and be able to inspect all areas of welding production.
2. The visual inspection is for surface conditions only and depends on the subjective opinion of the inspector.)

PERFORMANCE STANDARDS:

- Performance actions are standards.

(NOTE: The student benefits from this task by learning to inspect the welding process as well as the weld. As a result of this task training, the student should apply the visual inspection of the weld to his/her own work and improve welding procedures and welds.)

SUGGESTED INSTRUCTION TIME: Orientation Task (Skill will result only after repeated performances and the development of a thorough knowledge of welding.)

UNIT 8.0 - GUIDED BEND TESTING

OUTCOME-REFERENCED TESTS

This test sample is included to illustrate the level of testing currently used by the Welding Department, GTC. RE: Chapter #39 of the Welding Skills and Practices, Fifth Edition, and ASME Section IX, Part QW, Welding.

1. The guided bend test is used for:

___ a. stress analysis
b. welder performance qualification
c. company qualification
d. none of the above

2. For plate groove weld qualification test, place the correct "G" number with the applicable position (1G-2G-3G-4G):

a. flat ___G
b. horizontal ___G
c. vertical ___G
d. overhead ___G

3. For pipe groove weld qualification test, place the correct "G" number with the applicable position (1G-2G-5G-6G):

a. rotated ___G
b. horizontal ___G
c. vertical ___G
d. 45 degrees ___G

4. For fillet welds in plate, place the correct "F" number with the applicable position (1F-2F-3F-4F):

a. vertical ___F
b. plate axis 45° weld flat ___F
c. plate flat with axis of weld horizontal ___F
d. plate overhead with axis of weld horizontal ___F

5. The length and width of the test specimen should be:

___ a. 10" x 1.75"
b. 6" x 1.5"
c. 8" x 3"
d. 5" x 1.25"

6. The three types of bends made for a guided bend test are:

___ a. heel, throat, toe
b. transverse, obtuse, acute
c. oblique, longitudinal, horizontal
d. side, root, face

7. The results of the root bend will determine the acceptance or rejection of:

___ a. penetration and fusion of the first weld bead to the base metal
b. inner bead fusion
c. weld joint tensil strength
d. percent of root elongation

8. Face and root bends are normally used to examine:

___ a. spot welds
b. fillet welds
c. groove welds
d. plug welds

9. When sectioning a 4G plate specimen for the guided bend test, the number and type of bends made are:

___ a. three roots and three face
b. one face and one root
c. two roots and two face
d. none of the above

10. The side bend is considered to be a:

___ a. tension bend
b. guided bend
c. free bend
d. hot bend

11. Materials tested utilizing the side bend method is usually of a thickness exceeding _____ of an inch.

TRUE-FALSE

12. ___ The root bend is accomplished by bending the test specimen (strap) as to expose the face of the weld.

13. ___ A face bend is accomplished by bending the test specimen (strap) as to expose the finish side of the weld joint.

MULTIPLE-CHOICE

1. The root-bend specimen is used to check the degree of weld _____.

___ a. porosity
b. ductility
c. penetration
d. soundness

2. The soundness and the boundary between the weld metal and the base metal can be determined by _____ test.

___ a. a root-bend
b. a tensile strength
c. an etching
d. a free-bend

Unit 8.0 - GUIDED BEND TESTING

Answer Sheet

1. b

2. a. ___
   b. ___
   c. ___
   d. ___

3. a. ___
   b. ___
   c. ___
   d. ___

4. a. ___
   b. ___
   c. ___
   d. ___

5.

6. d

7.

8. c

9. b

10. b

11.

TRUE-FALSE

12.

13.

MULTIPLE-CHOICE

1. c

2. c

UNIT 9.0

BLUEPRINT READING

SUMMARY
BLUEPRINT READING
SUGGESTED INSTRUCTION TIME

BLUEPRINT READING UNIT/TASK		SUGGESTED HOURS
Unit 9.0		
9.01	Identify Information	25-30
9.02	Visualize Objects From Multiview Drawings	*
9.03	Determine Specifications	*

*See Task 9.01

TASK LISTINGS

BLUEPRINT READING

UNIT/TASK	DESCRIPTION
UNIT 9.0	
9.01	(Identify Information) Given a simple welding fabrication blueprint, identify pertinent information from the blueprint to the instructor's standards.
9.02	(Visualize Objects From Multiview Drawings) Given a welding blueprint or drawing, visualize the item to be welded or fabricated based on the three major views of a pictorial drawing.
9.03	(Determine Specifications) Given a welding blueprint, determine the measurements and given specifications from the print with 97 percent accuracy, meeting the instructor's standards.

UNIT 9.0 BLUEPRINT READING

TASK 9.01 IDENTIFY INFORMATION

PERFORMANCE OBJECTIVE:

Given a simple welding fabrication blueprint, identify pertinent information from the blueprint to the instructor's standards.

PERFORMANCE ACTIONS:

9.0101 Identify type, description, and purpose of lines (Alphabet of Lines) typically used of welding blueprints.

Identify lines that show:
- Visible edges of object
- Hidden features
- Line to show extent and direction of dimensions
- Adjacent parts, alternate positions, and lines of motion
- Leader line

9.0102 Identify welding symbols.

Using given information, interpret elements of welding symbols.

9.0103 Interpret the scale of the welding drawing and weld sizes.

9.0104 Find, read, and interpret the title block of the drawing.
- Tolerances
- Material specifications or instructors

9.0104 Locate and read notations on the drawing.

PERFORMANCE STANDARDS:

- On a given welding blueprint, identify information required to complete the welding with 100 percent accuracy in identifying lines, interpreting symbols, reading scales and other pertinent information identified by the instructor.

UNIT 9.0 BLUEPRINT READING

TASK 9.01 IDENTIFY INFORMATION (Con't.)

SUGGESTED INSTRUCTION TIME: 25-30 Hours*
*Includes Tasks 9.02 and 9.03

RELATED TECHNICAL INFORMATION:

- Fasteners
- Fabrication Prints

UNIT	9.0	BLUEPRINT READING
TASK	9.02	VISUALIZE OBJECTS FROM MULTI-VIEW DRAWINGS *

PERFORMANCE OBJECTIVE:

Given a welding blueprint or drawing, visualize the item to be welded or fabricated based on the three major views of a pictorial drawing.*

PERFORMANCE ACTIONS:

9.0201 Identify the major views of a pictorial drawing.
- Top
- Front
- Side

9.0202 Visualize a six sided object from a flat plane drawing.*
- Bottom
- Top
- Left
- Right
- Front
- Rear

9.0203 Visualize item to be welded or fabricated from given drawings.*

PERFORMANCE STANDARDS:

- Given a welding drawing or blueprint, visualize the item to be welded or fabricated and illustrate the finished item through a rough sketch or verbal description.*
- Must meet instructor's standards. 100 percent accuracy is desired.

SUGGESTED INSTRUCTION TIME: See Task 9.01

*"Visualize" = Actual performance must be measurable.

UNIT	9.0	BLUEPRINT READING
TASK	9.03	DETERMINE SPECIFICATIONS

PERFORMANCE OBJECTIVE:

Given a welding blueprint, determine the measurements and given specifications from the print with 97 percent accuracy, meeting the instructor's standards.

PERFORMANCE ACTIONS:

9.0301 Interpret measurements of the object from the dimensions.

9.0302 Determine type and sizes of welds.

9.0303 Determine specifications for weld or fabrication.

PERFORMANCE STANDARDS:

- With 97 percent accuracy, convert the measurements and specifications given in a welding blueprint into actual sizes and information that will be used to weld or fabricate the item.

SUGGESTED INSTRUCTION TIME: See Task 9.01

UNIT 9.0 - BLUEPRINT READING

OUTCOME-REFERENCED TESTS

COMPLETION

1. The ductility of a weld specimen with initial gauge lines 3 inches, and after the bend the elongation measures 3.6 inches, would be _____% in 3 inches.

2. The two specimens that are required in order to perform a guided bend test are a _____-bend specimen and a _____-bend specimen.

3. _____ testing is less expensive than tensile testing and achieves comparable results.

4. Information on weld symbols is placed to read from _____ to _____ along the reference line.

5. The width of a fillet weld is shown to the left of the weld symbol and is typically expressed in _____, _____, or metric units.

6. ___ Only one-half of an auxiliary view is shown when it is symmetrical.

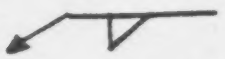
7. ___ The three principle views that are used to show the shape of an object are the front, top, and side.

8. ___ Fillets are rounded surfaces on outside edges and rounds are rounded surfaces inside corners.

9. ___ Weld instructions or materials specifications are indicated in the application block of the blueprint.

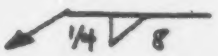
10. ___ The information in the revision block specifies what tolerances are to be maintained in a fabricating process.

IDENTIFY SYMBOLS



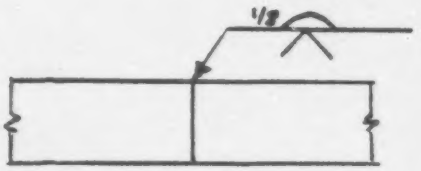
1. ___ This symbol represents a _____ weld.

2. ___ The perpendicular leg of this weld will be found on the _____ side.



1. ___ The size of this weld is _____.

2. ___ The length of the weld is _____.



1. ___ This symbol calls for a _____ weld to be made first.

2. ___ After the above weld is made, a _____ weld is to be made.

Unit 9.0 - BLUEPRINT READING

Answer Sheet

1. 20
2. face
   root
3. hardness
4. left to right
5. fractions, decimals
6. true
7. true
8. false
9. false
10. false

IDENTIFY SYMBOLS

1. fillet
2. left

1. 1/4
2. 8

1. groove
2. back

END OF
TRAINING TASK

CAREER OPPORTUNITIES

IDENTIFY POST-SECONDARY CAREER
DEVELOPMENT OPPORTUNITIES

PERFORMANCE OBJECTIVE:

Given an orientation to similar post-secondary vocational education programs, primarily the Welding program at Greenville Technical College and evening development programs for the welding trade, a report of skill competencies development during secondary training and information as necessary; identify post-secondary career development opportunities.

PERFORMANCE ACTIONS:

1. Identify:
   a. Need for additional training at the post-secondary level.
   b. Benefits from additional training.
2. a. Identify post-secondary training programs available at GTC.
   b. Identify how post-secondary (GTC) training differs from secondary training in welding.
3. Visit GTC program of possible interest. Talk with instructor, department head, or admissions counselor at GTC.
4. Determine with secondary and post-secondary assistance if exemption of post-secondary level training is recommended.
5. Accomplish the required steps to apply or test for exemption. (Optional)

PERFORMANCE STANDARDS:

- Identify post-secondary training opportunities in welding or a related area at GTC.

SUGGESTED INSTRUCTION TIME: Typically, integrated throughout entire program.

"PROFICIENCY REPORT"

WELDING

PROFICIENCY EVALUATION AID

This dsecriptive aid is designed to possibly assist the welding instructor in standardizing the proficiency evaluation of students.

PROFICIENCY	LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Description	No skill level demonstrated or proficiency training not given in the skill.	Individual's skill level is not that generally expected for entry-level employee.	Individual's skill level probably is that expected for entry-level employment, but the individual probably will need close on-the-job supervision for a while longer.	Individual's skill level is that generally expected for entry-level employment.	Individual's skill level is equal to that of a worker with some on-the-job experience.
		PLANNING PROJECTS			
Procedure	"	Did not work from a plan.	Some steps wrong or missing.	A few minor changes needed.	Plan completed; no changes needed.
Working drawing or sketch	"	Incorrectly drawn, poor dimensioning.	Able to use with some changes.	Minor needed dimensions omitted.	Able to use; no changes needed.
Fabrication and usefulness of project ability	"	Not usable for intended purpose.	Able to use with some changes.	No changes made; could be improved.	Well fabricated for purpose intended.
Problem-solving ability	"	Solved no problems.	Solved only easy problems.	Solved nearly all problems.	Solved all problems.
		FABRICATED-WELDED PROJECTS			
Appearance, Welds, Joints	"	Assembled poorly; not finished.	Not very neatly assembled.	A few final touches needed.	Clean, neat, and commercial in appearance.
Method of fabrication	"	Used own method; "cut and try".	Made poor use of methods shown.	Followed correct methods most of the time.	Use the demonstrated methods.
Tools	"	Careless with tools, equipment.	Used tools and equipment correctly most of the time.	Correctly used tools and equipment at all times.	Correctly used and cared for tools, etc., at all times.
Materials	"	Wasteful and careless with materials.	Wasteful with materials at times.	Usually careful of materials.	Conserves materials at all times.
Accuracy of work.		Failed to meet specifications.	Work is approximately correct.	A few measurements are off.	Meets all specifications.
Working time.	"	Little or no effort made to use time wisely.	Time used fairly well.	Wasted small amount of time.	Used time to best advantage.

PROFICIENCY REPORT
for

_____
Vocational Course

Student: _____

High School: _____

Vocational Center: _____

Date Training Initiated: _____
First Year Completed: _____
Second Year Initiated: _____
Second Year Completed: _____

Instructor: _____

DIRECTIONS: The purpose of the proficiency report is to communicate to the student, other instructors, or potential employers the abilities that a student has demonstrated to the instructor in vocational training. Mark each task as soon as possible after instruction or skills demonstration. If instruction is not aimed as task proficiency, or if only an orientation or introduction to the task was provided, DO NOT mark a proficiency level or mark Level 0. Levels 1-4 indicate that instruction was given and the proficiency may be interpreted as follows:

Level 0	No skill level demonstrated or proficiency training not given in the skill.
Level 1	Individual's skill level is not that generally expected for entry level employment.
Level 2	Individual's skill level probably is that generally expected for entry level employment, but the individual probably will need close on-the-job supervision for a while longer.
Level 3	Individual's skill level is that generally expected for entry level employment.
Level 4	Individual's skill level is equal to that of a worker with some on-the-job experience.

For further description of the levels of proficiency, see the "Credentialing Process and Proficiency Report" section of the Policies and Procedures Guide for Articulation Between The School District of Greenville County and Greenville Technical College.

Student: _____

PROFICIENCY REPORT

WELDING

	TASK	Proficiency Level 0	Level 1	Level 2	Level 3	Level 4	Instructor's Initials	Date Completed
UNIT 0.0	WELDING							
0.0	Orientation							
UNIT 1.0	WELDING SAFETY							
1.01	Safety: General							
1.02	Classroom Safety							
1.03	Apply Fire Safety Rules and Procedures							
1.04	Apply Electrical Safety Rules and Procedures							
1.05	Personal Safety in Welding							
1.06	Safe Practices in Welding							
UNIT 2.0	WELDING MATH							
2.01	Basic Welding Math - Fractions							
2.02	Basic Welding Math - Decimals							
2.03	Basic Welding Math - Volumes							
2.04	Basic Welding Math - Areas							
2.05	The Metric System							
UNIT 3.0	MEASURING							
3.01	Measuring in Welding							
UNIT 4.0	WELDING I - OXYACETYLENE							
4.01	Oxyacetylene Cutting/Welding Terminology							
4.02	Oxyacetylene Cutting/Welding Safety							
4.03	Perform Soap and Water Test (Safety)							
4.04	Identifying Oxygen and Acetylene Gases and Cylinder Handling							
4.05	Set Up Oxyacetylene Cutting/Welding Station							
4.06	Clean Oxyacetylene Cutting/Welding Tips							
4.07	Lighting the Torch							
4.08	Adjusting Flame							
4.09	Oxyacetylene Cutting							
4.10	Preparing The Joint							
4.11	Carrying The Puddle (Fuse)							
4.12	Run a Bead With Filler Rod							
4.13	Weld Open Butt Joint, All Positions							
4.14	Weld T-Joint, All Positions							
4.15	Fillet Weld, Lap Joint, Flat and Overhead Positions							
4.16	Weld Corner Joint (Outside) Flat Position							
4.17	Construct Pipe Weld in Fixed Position							
4.18	Braze Mild Steel							
UNIT 5.0	ARC WELDING							
5.01	Introduction (Principles) of Arc Welding							
5.02	Safety in Arc Welding							
5.03	Machines and Accessories							
5.04	Select Electrode							
5.05	Striking and Maintaining (Substaining) an Arc (Flat Position)							
5.06	Chip Slag Using Chipping Hammer							
5.07	Run Short Beads, Flat Position (Training Task)							
5.08	Run Continuous Beads, Flat Position (Training Task)							
5.09	Weld Weave Bead Pattern							
5.10	Prepare Joint							
5.11	Set Up and Make Stringer Beads on Flat Plate in All Positions							
5.12	Set Up and Tack Weld Joints							
5.13	Set Up and Multi-Pass Weld T-Joint, All Positions							
5.14	Construct Open Butt Weld, All Positions							
5.15	Construct Lap Joint Weld, 3/8 Inch Equal Legs, Three Passes							
5.16	Construct an Outside Corner Weld in The Vertical Up and Down Positions							
5.17	Construct Groove Weld on Pipe in Flat Axis, Vertical, and Diagonal Axis Positions							

		Proficiency Level 0	Level 1	Level 2	Level 3	Level 4	Instructor's Initials	Date Completed
UNIT 6.0	OPERATE GAS METAL ARC WELDING EQUIPMENT (MIG)							
6.01	Introduction to GMAW Welding							
6.02	GMAW Welding Safety							
6.03	Set Up and Shut Down GMAW (MIG) Equipment							
6.04	Maintain Gas Metal Arc Welding Gun (Torch)							
6.05	Weld Stringer Beads With GMAW Equipment, Flat Position							
6.06	Weld Carbon Steel With GMAW Equipment Butt Joint, All Positions							
6.07	Weld Carbon Steel, T-Joints, With GMAW Equipment, Flat and Vertical Position (Up/down)							
6.08	GMAW Weld Pipe in Fixed Position(s), Downhill							
UNIT 7.0	GAS TUNGSTEN ARC WELDING (TIG)							
7.01	Introduction to (GTAW) Welding							
7.02	(GTAW) Safety							
7.03	Prepare for GTAW Welding, Startup Equipment, Adjust, Shut-down							
7.04	Disassemble and Clean GTAW (TIG) Torch Assembly							
7.05	Carrying the Puddle							
7.06	Weld Stringer Beads, Mild Steel, and Flat Position, Using GTAW Equipment							
7.07	Weld Carbon Steel With GTAW (TIG) Equipment, All Positions							
7.08	Weld Stainless Steels With GTAW (TIG) Process, All Positions							
7.09	Weld Aluminum or Aluminum Alloys With GTAW (TIG) Equipment, Flat, T, and Open Butt							
UNIT 8.0	WELD TESTING							
8.01	Make Guided Bend Test of Butt Joint							
8.02	Test Fillet Welded Joint							
8.03	Conduct Visual Inspection of Weld							
UNIT 9.0	BLUEPRINT READING							
9.01	Identify Information							
9.02	Visualize Objects From Multi-view Drawings							
9.03	Determine Specifications							

ILLUSTRATION
OF
GTC EXEMPTION
TESTING

SAMPLE TEST FOR EXEMPTIONS OF WLD 113

Oxyacetylene Procedures

1. Vertical Butt Weld
2. Horizontal Butt Weld
3. Braze - Flat Bead
4. Cutting - Straight Line and Curves

E 6010 Electrode

1. Vertical Fillet
2. Overhead Fillet

E 7018 Electrode

1. Vertical Fillet
2. Overhead Fillet

Ralph Kneisley

Ralph Kneisley

Received 2-8-83
from Greenville Technical College

282

SAMPLE GTC - WELDING
OUTCOME-REFERENCED TEST

Chapters 7, 8, and 9 (Textbook)

WLD 123 2nd Quarter

1. In ARC welding, what will a long arc produce? _____
_____

2. The _____ _____ and _____ motion are two methods which can be used to strike the arc.

3. The arc should be maintained at approximately what length? _____
_____

4. Why should the holder never be placed on the work bench while the current is on? _____

5. Name the five essentials of arc welding.
   1.
   2.
   3.
   4.
   5.

6. How will the electrode melt if the arc is too long? _____
_____

7. Why is the use of the short arc important? _____
_____

8. What causes undercutting, and how can undercutting be avoided?
_____
_____

9. What items must be taken into consideration when selecting an electrode?
   1.
   2.
   3.
   4.

10. Once a joint is tacked, the remaining passes to be deposited are called?
    1. The first pass or _____
    2. The next layer or _____
    3. The final pass or _____

OUTCOME-REFERENCED TEST

Chapter 14 (Textbook)

WLD 123 2nd Quarter

1. What is an important point to remember in welding carbon steels?
   _____

2. Where carbon goes into a solution form and becomes evenly distributed (austentic structure), what happens to the carbon steel weld if the structure is cooled quickly? Becomes extremely hard and brittle. Underbead cracking can be expected in weld and base metal.

3. What series electrodes will produce a good weld on mild steel?
   _____ and _____

4. What is the carbon content of medium-carbon steel? _____
   to _____

5. What is the carbon content of high-carbon steels? _____
   or _____

6. What type electrodes are used to weld high-carbon steels? _____
   _____

7. List four advantages of preheating before welding?
   1.
   2.
   3.
   4.

8. The preheat range for mild steel should be between _____
   degrees to _____ degrees F.

9. What causes porosity in a weld? _____
   _____

OUTCOME-REFERENCED TEST

Chapter 32 (Textbook) Pipe Welding

WLD 120 3rd Quarter

1. How many tacks should be placed on most pipes before welding?
   a. 1
   b. 2
   c. 3
   d. 4

2. How long should these tacks be?
   a. 2 inches
   b. 1 1/2 inches
   c. 3/4 inches
   d. No certain length

3. What series rod should be used when higher strengths are needed?
   a. E60XX series
   b. E70XX series
   c. Nickel alloy
   d. None of the above

4. Most pipe welding is done with the?
   a. E6010 or E6011
   b. E6010 or E70S-2
   c. E6012 or E6013
   d. The best rod suited for the pipe

5. Most thin wall pipe is welded with the _____ technique?
   a. uphill
   b. downhill
   c. rolling
   d. all around

6. What is the specific function of the hot pass?
   a. burn out slag
   b. melt down knots on root
   c. to produce a smooth filler
   d. because it is an ASME procedure

REFERENCES

Althouse, Andrew D.; Turnquist, Carl H., and Bowditch, William A. Modern Welding, South Holland, IL: The Goodheart-Willcox Co., Inc., 1980.

Althouse, Andrew D.; Turnquist, Carl H., and Bowditch, William A. Modern Welding Instructor's Guide and Answer Key, South Holland, IL: The Goodheart-Willcox Co., Inc., 1980.

Baird, Ronald J. Oxyacetylene Welding Basic Fundamentals, South Holland, IL: The Goodheart-Willcox Company, Inc., 1980.

Baird, Ronald J. Oxyacetylene Welding Basic Fundamentals Instructor's Answer Key, South Holland, IL: The Goodheart-Willcox Company, Inc., 1980.

Bragg, Jack M., and Hunter, Wallace D. PhD., Combination Welding, Pensacola, FL: The University of West Florida Technical & Vocational Studies, and The Florida Department of Education, Division of Vocational, Technical and Adult Education, 1975.

Curriculum Standards for Welding, Montgomery, AL: State Department of Education Vocational/Technical Education, 1982.

Giachino, Joseph W. Arc Welding, Alsip, IL: American Technical Publishers, Inc., 1977.

Giachino, Joseph W., and Beukema, Henry J. Print Reading for Welders 2nd ed., Alsip IL: American Technical Publishers, Inc., 1978.

Giachino, Joseph W., and Beukema, Henry J. Answer Key for Print Reading for Welders 2nd ed., Alsip IL: American Technical Publishers, Inc., 1978.

Giachino, Joseph W., and Weeks, William. Welding Skills and Practices, 5th ed., Chicago, IL: American Technical Publishers, Inc., 1976.

Giachino, Joseph W. Student Activity Manual for Welding Skills and Practices, Chicago, IL: American Technical Publishers, Inc., 1976.

Giachino, Joseph W., and Weeks, William. Examination Answer Key for Student Guide for Welding Skills and Practices, Alsip, IL: American Technical Publishers, Inc.

Giachino, Joseph W. Instructor's Guide for Welding Skills and Practices, American Technical Publishers, Inc., 1977.

Hobart School of Welding Technology, Hobart Welding Guide, Troy, OH: 1980.

Hobart School of Welding Technology, Training in Advanced Shielded Metal-Arc Welding, Troy, OH: 1975.

Hobart School of Welding Technology, Training in Basic Gas Metal-Arc Welding, Troy, OH: 1981.

Hobart School of Welding Technology, Training in Gas Tungsten Arc Welding, Troy, OH: 1979.

Hobart School of Welding Technology, Training in Oxyacetylene Welding, Cutting and Brazing, Troy, OH: 1976.

Notgrass, Troy, Welder Coordinator's Guide, Austin, TX: The University of Texas at Austin, Instructional Materials Center, 1976.

Notgrass, Troy, Welder Student's Guide, Austin, TX: The University of Texas at Austin, Instructional Materials Center, 1976.

Teacher's Guide for Competency-Based Vocational Curriculum for Welding, Pittsburgh, PA: Associated Educational Consultants, Inc., West Virginia State Vocational Curriculum Lab., Cedar Lakes, 1980.

Walker, John R. ARC Welding, South Holland, IL: The Goodheart-Willcox Company, Inc., 1981.

Walker, John R. ARC Welding Basic Fundamentals, South Holland, IL: The Goodheart-Willcox Company, Inc.

Welding, Stillwater, OK: State Department of Vocational and Technical Education, 1971.

APPENDIXES

Appendix A	Tasks Not Addressed
Appendix B	Joint Articulation Agreement
Appendix C	Instructor's Signed Agreement to Articulate
Appendix D	Philosophy of Articulation Guide Design
Appendix E	Purposes of Articulation Guide
Appendix F	Definitions of Terms
Appendix G	Directions for Tests
Appendix H	Responsibility Sheet
Appendix I	Binder Design

TASKS NOT ADDRESSED

(OPTIONAL)

SMAW

1. (Hard Surface Steel With ARC)
   Given steel work piece requiring hard surfacing, job description, necessary tools and materials; build-up (hard surface) to specifications.

2. (ARC Weld Cast Iron)
   Given a section of broken (weldable) cast iron, SMAW unit and necessary materials and job description; weld repair the cast iron so that it conforms to its original configuration and strength and passes an operational test.

3. (Weld Head and Corrosion Resistant /stainless/ Steel)
   Given SMAW equipment, materials, and job order describing the stainless steel, weld job, current and electrodes; weld stainless steel joints using fillet and groove welds so that visual inspection reveals smooth and continuous welds, complete penetration, fusion between the weld bead and base metal, and no cracks, undercutting, or overlap.

OTHER TASKS

1. (Fabricate Aluminum Objects)
   Given a job order with sketch requiring fabrication of aluminum objects, necessary equipment, tools, and materials; fabricate the object so that it conforms to specifications and is usable for the intended purpose.

2. (Fabricate Protective Devices /burgular bars/ for Windows)
   Given a job order with sketch and accurate measurements requiring the fabrication of a window protective device (burgular bars), and the necessary equipment, tools, and materials; fabricate the device so that it meets specifications.

3. (Fabricate or Repair Metal School Furniture and Work Stands)
   Given a job order requiring the repair of metal school furniture or work stands and the necessary equipment, tools, and materials; fabricate the repair to specifications so the object is usable for its intended purpose.

THE SCHOOL DISTRICT
OF GREENVILLE COUNTY

GREENVILLE TECHNICAL COLLEGE

TO: All Administrators, Staffs and Faculties, The School District of Greenville County and Greenville Technical College

SUBJECT: Application and Implementation of the Policies and Procedures for the Articulation of Similar Vocational Training Programs of Instruction

Since 1976, The School District of Greenville County and Greenville Technical College have been working toward making the articulation of vocational education programs a viable and valid reality. Through joint efforts in the Occupational Education Articulation Program, The School District of Greenville County and Greenville Technical College fully support the concept of articulation and agree upon the purposes of the articulation program.

This Policies and Procedures Guide has been developed as a joint effort of The School District of Greenville County and Greenville Technical College with the assistance of individuals representing the institutional administrative units, involved faculty, and the local business and industrial community. The Policies and Procedures Guide is designed to assist the articulation of very similar programs of vocational training between the secondary and post-secondary, public, vocational training institutions in Greenville County.

Appreciation is expressed to participants at both institutions for the joint effort of this endeavor.

J. F. Hall
J. F. Hall
Superintendent
The School District of
Greenville County

Thomas E. Barton
Thomas E. Barton
President
Greenville Technical College

TASK FORCE COMMITTEE
AGREEMENT TO ARTICULATE
VOCATIONAL EDUCATION

Articulation provides a system whereby secondary and post-secondary instructors can cooperate effectively in providing a continuous occupational development program where the level and type of vocational training that leads to entry-level employment skills will be clear to instructors, other educators, students, and potential employers.

The concept of articulation and the articulation program are supported fully be The School District of Greenville County and Greenville Technical College which have agreed upon a statement of purpose for the articulation of similar vocational education programs in Greenville County.

The articulation program in Greenville County is a joint effort of The School District of Greenville County and Greenville Technical College to develop a continuous program of vocational training so that students may continue their career preparation without loss of time or waste of effort in repeating tasks which have been learned previously and demonstrated. Articulation program activities are designed to help remove unnecessary gaps or overlap in student learning which may occur when a student completes a secondary vocational program and continues career development at the post-secondary level in a similar occupational field.

To implement articulation, instructor representatives from the participating institutions have met as a task force committee to develop this articulated, performance-based instruction guide which describes the secondary vocational program and which provides the parameters for vertical articulation.

Vertical articulation shall include recognition of the occupational competencies demonstrated by secondary graduates of articulated vocational programs.

It is agreed that...

The task force committee instructor representatives from The School District of Greenville County and Greenville Technical College mutually recognize the value of occupational education provided by each institution.

The task force committee instructor representatives will take the necessary actions, approved by their administrations, to ensure that this agreement to articulate is fulfilled including interpreting the program to students.

It is understood that periodic review of the articulated task objectives, performance actions, minimum standards, and outcome-referenced measures will be necessary to ensure that a valid training program is serving the needs of the community and the students.

Each task force committee participant hereby agrees to notify the others of any changes which modify the articulated, performance-based vocational program described in this guide so that each articulation guide, and where appropriate the articulation program, may be revised mutually so that articulated occupational training in Greenville County will conform to the minimum standards outlined in this guide.

This agreement to articulate establishes the necessary framework for lateral as well as vertical articulation.

AGREED UPON BY THE TASK FORCE COMMITTEE PARTICIPANTS ON THIS DAY,
May 2, 1983
date

Name	Institution/School
J. Arrington	Boiling Springs Vocational Center
W. W. Sobell	Foothills AVC
Ralph Finley	Greenville Tech.

PHILOSOPHY OF ARTICULATED, PERFORMANCED-BASED INSTRUCTION GUIDE DESIGN

The design of the articulated, performance-based instruction guides and the articulation program is based on a philosophy that the vocational education curriculum should be for career training with few fringe or non-related subjects. The student should be given the basis to do useful skilled work upon graduation and employment. The vocational program graduate should have a background which will allow him/her to learn and advance as rapidly as possible on the job, but it should not include subject matter which will not be applicable to his/her work for years. When subject matter is introduced that will not be applicable to the graduate's work for years, it may put the graduate out of perspective. The result might be that the graduate may try to force applications which do not exist, simply because the information is in his/her repertoire. Thus, the purpose of vocational training by the articulated, performance-based instruction guides is to prepare graduates for successful entry into a skilled trade.

To ensure that the design of the articulated, performanced-based instruction guides is conforming to the philosophies of both the secondary and post-secondary institutional participants, a periodic review of the guide design and philosophy is recommended.

PURPOSES OF THE ARTICULATED INSTRUCTION GUIDE

The articulated instruction objectives guide are is expected to serve the following purposes:

1. The guide serves as the primary vehicle for the articulation of subject matter in similar vocational training programs between the vocational education centers, high schools, and Greenville Technical College through use by instructors at both levels as a reference in preparing instruction.

2. The guide provides a listing of the minimum tasks that a student or worker is expected to perform in the conduct of a specific level job in the area of vocational training or work of concern.

3. The guides identify the primary detailed instruction objectives, performance objectives which are based upon the task listings. The tasks are listed in the sequence of complexity, with the least complex task being listed first, except where a task must be performed as a prerequisite to performance of another task.

4. The guides identify the tasks performed (actions, steps, sets of skills) and related technical information which must be taught and learned to accomplish each major instruction objective. The tasks performed represent the minimum skills and related information required for adequate occupational proficiency in the performance objectives.

5. The guides designate the instructional contact hours necessary to provide the required instruction, as required by appropriate educational agencies or offices and as estimated by the instructor-participants on the Vocational Articulation Project Task Forces, and based on the time required to teach the average learner to perform the task. The time estimated is based on having the essential equipment, facilities and instructional aids required to provide the instruction, whenever the class size is limited to an acceptable number.

6. The guides identify the performance standards to be met for occupational proficiency in the task. Performance standards used are those considered to be minimum business or industry standards. The ability to meet the listed standards of performance will be considered as qualification for advanced instruction in the vocational program.

7. The guides provide direction in the conduct of sequential vocational competency instruction by modules or job tasks, resulting in qualification by the learner to perform limited skill specialist jobs of

progressively higher skills until the program objective is reached (i.e., file clark to executive secretary, etc.). As the student becomes proficient in the performance of tasks in successively more complex modules, more marketable competencies are gained and may be identified as the lower job qualifications of a specialist.

Through this procedure, even the slower student is provided an opportunity to eventually gain sufficient skills to perform adequately as a specialist at some level in the vocational field, even if the student is unable to complete the total program of training.

The standardized sequence of activities of the vocational instruction modules will facilitate lateral articulation between vocational education centers in the School District and will simplify vertical articulation when training is continued at Greenville Technical College articulating to employers.

8. The guides provide a descriptive listing of equipment required to conduct the program of vocational training. The equipment listed is considered to be the type and quantity essential for the conduct of instruction to prepare students for entry-level employment in the vocational field. It may be necessary to delay teaching some tasks involving special equipment, if that equipment is not available at all instructional sites, or to move students and equipment together as necessary to teach skills.

9. The guide provides information about requirements or limitations that typically are involved in the performance of the task, environmental conditions and physical demands, and able to perform the task.

10. The guides provide a list of standardized performance test items/ and outcome-referenced measures to be used in the determination of vocational proficiency. As long as the specifics are not provided, the test items listed cannot be compromised easily and could serve as study guides.

11. The tasks listed in the guide are the minimum requirements for job qualification under average circumstances in a regional market. It is understood that there may be unlisted tasks that some employers may require the worker to do in the occupation, when in their employment. In addition, there may be unlisted tasks, such as mental process tasks, that are not stated but that may occur and that should be considered in instructional planning or testing.

Instructors may teach skills and related technical information other than what is shown in the guides. Provision of additional information should be limited to the students who have completed the requirements for the tasks emphasized in the instructional guides. The change of tasks in the guides should be based on task force committee agreement to ensure lateral and vertical articulation.

12. It is expected that there will be updating and correction of items in the articulated instruction guide. Participants are to be sure that the contents are valid and consistent with business and industry requirements. Recommendations should be submitted to the Vocational Articulation Program office which will assemble and present them to the appropriate committee for review and possible adoption.

13. Typically, the teacher/instructor should not plan to conduct instruction in a given articulated module unless the capability exists to conduct all of the instruction to meet the instructional objectives, with the result that the successful student is qualified to perform the tasks identified within the module.

14. An underlying philosophy in vocational training is that it is better to prepare the student to be fully qualified to perform all of the tasks in a limited group of modules in a vocational field and be qualified at a lower job level rather than to be only familiar with a large number of task descriptions or duties and qualified to perform none of them fully. For higher levels of job qualification beyond the secondary level, the student or worker is encouraged to enroll at Greenville Technical College.

15. Generally, vocational programs will include certain basic modules or courses of instruction without which the student would not be considered vocationally qualified at any level. Basic modules typically will be identified and taught early in the program sequence.

16. The instruction guides provides information essential to help the vocational student who completes training at the secondary level and continues career development training at the post-secondary level in a similar program receive appropriate credit for the articulated vocational training that has been mastered at the secondary level.

DEFINITIONS OF TERMS

The following definitions of terms are applicable to the articulated, performance-based instruction guides developed as products of the Occupational Education Articulation Program.

Behavior: The actions of a person (specifically, job or job training actions). Behavioral actions include both overt, those that can be observed, and covert, those not observable outwardly. Performance may be interchanged with behavior in the project. (See also Performance Actions).

Concept: A group of ideas that may be classed together or that are similar.

Criteria: A standard by which performance may be measured, usually considered the minimum standard.

Domain: A cluster of related jobs.

Duty: One of the distinct major activities involved in the work performed and comprising related tasks.

Evaluation: When comparison is made between a measurement and a standard and judgment is passed on the comparison.

Item: A single stimulus or stimulus pattern that calls for a single response or set of responses. It is one sample of behavior or performance. The response may be simple or complex.

Job: The duties or tasks actually performed by a specified individual.

Knowledge: In this project, knowledge refers to acquired covert behavior which facilitates skills and performance, such as the theoretical information of what should be done under given circumstances, and in what order of sequence performance should occur to accomplish the objective.

Measurement: The process of determining the extent some characteristic is associated with the student.

Module: Modules in the pilot Drafting and Business and Office Education curriculum modifications in the Occuptional Education Articulation Program have been designed to

coincide secondary level training with post-secondary level similar areas of training.

Another method of developing modules might be for modules to represent an identifiable, complicated task or job area involving a number of sub-tasks such as "Electrical Systems" in Automotive Mechanics.

Norm-referenced Evaluation: In norm-referenced evaluation, measures are dependent on a relative standard. Measures compare the capabilities of one student to those of other students.

Objective: (See Performance Objective) A stated desired outcome of training or the end result of the job, task, or performance actions. Objectives referred to in this project will be terminal objectives, generally representing a specific job function.

Occupational Education: An organized sequence of learning experiences consisting of vocational theory, practice, and skills taught to students on a regular or systematic basis.*

*Reference: Standards of the Delegate Assembly (Atlanta: Southern Association of Colleges and Schools, Commission on Occupational Education, December, 1972) p. 12.

Outcome-referenced Evaluation: Outcome-referenced, or criterion-referenced, measurement provides a standard of achievement for the individual as compared with specific behavioral objectives and therefore provides information about the degree of competence attained by the student.

The outcome-referenced measure is a performance or other measure based upon a performance objective, the accomplishment of which measures attainment of that objective.

Performance: Performance is used in this project to refer to a job or task which results from a set of sequential actions or steps.

Performance Actions: A series of steps, generally arranged in a sequence ordinarily followed, which when completed may result in the accomplishment of a performance objective (performance of a task).

Performance actions may be referred to as a set or sets of skills, functions, or steps. V-TEC (Vocational-Technical Education Consortium of States) catalogs generally describe performance actions in the "performance guide" of their format.

Articulated, Performance-based Instruction Guide: A comprehensive collection of performance objectives, performance actions to obtain those objectives, suggested hours for instruction (for planning purposes), performance standards, related technical

information, and outcome-referenced measures, as well as general secondary level and post-secondary level descriptions of similar courses for the purposes of aiding lateral and vertical articulation concerning the subject area.

Performance-based Instruction: Performance-based (competence-based) instruction is based on the competencies or tasks performed by on-the-job workers. Everything in a performance-based instruction system is made public beforehand. There are no surprises for student, teacher, counselor, or employer. When the student begins a program, information is available to tell the student exactly what competencies are expected to be developed as a result of the instructional program, how and against what standards or criteria the student will be evaluated, and how the student's competencies will be communicated to the student, instructors, and to employers. A performance-based instructional system tells the student exactly what the student must learn, teaches the student that skill or knowledge, and then tests on mastery of that specific competence.

Performance Objective: A statement in precise, measurable terms of a particular behavior to be exhibited by a learner under specified conditions. It possesses each of the elements or characteristics specified below:

Conditions under which the performance is to take place.

Behavior Desired or expected of the student (things to be done, the performance desired).

Standards to determine how well the performance is to be done (criteria).

Performance Test: A performance test requires the student to demonstrate (master) the desired behavior of the objective (accomplish a job-like task) under controlled conditions and according to predetermined standards. The controlled conditions allow the student to demonstrate the desired behavior and the conditions remain consistent from student to student.

Skill: Primarily, skill refers to overt, observable performance, however, it is recognized that there are covert skills required in some performances.

Step: Step is used to refer to a task or action, generally as a sequence of steps involved in the accomplishment of a performance objective or job.

Systems Approach: The systems approach to instruction emphasizes the specification of instructional objectives, precisely controlled learning experiences to achieve the objectives, criteria for performance, and evaluative information.

Task: A task is a set of skills (set or sets of functions, actions, or steps) the student must perform to accomplish the job (training). A task may be described as a logically related set of actions necessary or required to complete the job objective. Several tasks could be referred to as a duty.

Task Analysis: Task analysis is breaking down a learning task (objective) into component tasks each of which must be mastered as a prerequisite to mastery of the total job.

Task List: A listing of tasks (performance objectives) performed by incumbent workers (students in training) within a domain of interest (course of study).

Test: An event during which the student is asked to demonstrate some aspect of knowledge or skill is a test. It can be a single test item, but usually it consists of several items.

INSTRUCTIONS FOR ANSWERING OUTCOME-REFERENCED TEST ITEMS

Typically, eleven (11) different types of outcome-referenced test items may be used in the competency test.

1. True-False
2. Completion (Fill-in Blanks)
3. A Combination of True-False and Completion
4. Multiple-Choice
5. Matching
6. Identification
7. Short Answer
8. Long Answer
9. Program Product of Performance Test
10. Simulated Performance Test
11. Actual Performance Test

An example of each type of test item is included. Carefully study the illustration test item and the directions for answering the question. These directions will not be given again. Your test questions may vary slightly in the format, however, the instruction should be applicable. Where necessary, the instructor will supplement these instructions for answering outcome-referenced test items.

Do not guess. Guessing does not add to your knowledge, even if you happen to guess right. If you do not know the answer skip the test item and go to the next question. Remember: Enter your answers in the blanks provided on the separate answer sheet, if used.

---

1. TRUE-FALSE

   Directions: Read the statement carefully. Decide whether it is true or false. Answer by marking T or F in the blank provided to the right (or, if answer sheet requires, mark "X" in the appropriate (T) or (F) parenthesis, or "circle" T or F).

   Example: Lumber shrinks across the grain of the board. (T) (F)

2. COMPLETION (Fill-in Blanks)

   Directions: Complete the statement by printing on the blank line the word or words which make a complete and correct statement.

   Example: Proper edge spacing will restrict ___?___ and ensure good weld penetration. distortion

3. COMBINATION OF TRUE-FALSE/COMPLETION

Directions: If the statement is correct, in the parenthesis mark (T) or answer true, as required. If the statement is incorrect, mark (F) in the parenthesis and fill in the blank provided with the appropriate word or term which, if substituted for the underlined word, would make the statement correct.

Example: A pantry chef usually is the head chef's first assistant. (T) (F)

sous

4. MULTIPLE-CHOICE

a. Directions: You are given three or four choices from which to make a complete and correct statement. In the blank answer space provided, write in the "letter" indicate the best choice.

Example: The head chef's first assistant is a ? .

a. junior chef
b. sous chef
c. pantry cook

b

b. Negative Answer Multiple-Choice

Directions: If the multiple-choice question includes the word EXCEPT, you should look for the choice that does not fit the question. Read the entire question carefully before you choose your answer.

Example: All of these could cause high starter current draw EXCEPT:

a. work starter bushing
b. bad starter relay
c. grounded field coils
d. grounded armature

b

5. MATCHING:

Directions: For each given item in the left hand column, match it with the appropriate item from the right hand column. Write the letters of the correct or best answer in the appropriate blanks.

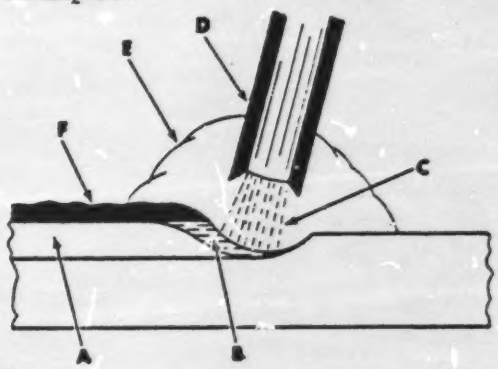
Example: Match these metric terms on the left with their proper equivalents.

b	deca	a. thousands
c	meter	b. tens
a	kilo	c. units of length measurement

6. IDENTIFICATION

Directions: Identify each labeled part of the illustration below and write the name next to the appropriate letter in the blank provided.

Example:



a. base metal
b. molten metal
c. arc
d. electrode
e. gas shield
f. slag

7. SHORT ANSWER

Directions: Write the correct answer in the blank provided.

Example: What type of electrode is best for vertical and overhead welding? fast-freeze

8. LONG ANSWER

Directions: Using as few words as possible, write the answer to the question in the blank provided.

Example: What should be done if the electrode welds fast to the work?

"Electrode should be broken loose by twisting or bending the holder."

9. PROGRAM PRODUCT OR PERFORMANCE TEST

Definition: Concrete project or production accomplishments during training are used to test knowledge or skill. Typically, test pressures are missing and the student may have had help in completing the task.

Directions: Instructor will observe student during training and by checklist or rating scale will rate student's performance or knowledge.

Example: Given an oven for baking, food items, and necessary implements and equipment; load the oven with foods to be baked. All items on a checklist used to rate performance must receive an acceptable rating. The task must be accomplished within 15 minutes.

CHECKLIST

(Load Oven Racks)

ACTIVITY	RATING	
	Acceptable	Unacceptable
1. Gathered needed supplies.		
2. Used needed supplies.		
3. Pulled oven rack partially out while loading.		
4. Stacked oven shelves 8 inches apart for baking.		
5. Placed food on rack so that heat circulated adequately.		
6. Followed appropriate safety precautions.		

10. SIMULATED PERFORMANCE

Definition: Contrived situation, resembling tasks the graduate will be required to do on the job. This form of test is useful for evaluating transferable skills such as reasoning, attitudes, and psychomotor skills necessary for occupational success.

11. ACTUAL PERFORMANCE TEST

Definition: Exhibits the advantage of realism, but may be too late to help either the student or the vocational program correct failures.

Example: Given an automobile with a leaking pinion seal, access to proper tools and equipment, replacement parts, and service manual; replace the pinion seal according to manufacturer's recommended procedures. The job should be completed within 2 hours. The manufacturer's specifications must be met and the completed job must meet the instructor's standards.

THIS DOCUMENT AND BINDER ARE THE PROPERTY OF THE SCHOOL DISTRICT OF GREENVILLE COUNTY OR GREENVILLE TECHNICAL COLLEGE

This document and binder, produced by the Occupational Education Articulation Program, have been funded through the South Carolina Appalachian Council of Governments and are the property of The School District of Greenville County or Greenville Technical College.

Except for document and binder copies that have been placed in libraries or shared with educational organizations, the documents and binders are issued on accountability basis.

Documents and binders issued to instructor participants remain the property of the issuing institution. Should a vocational instructor leave the employment of The School District of Greenville County or Greenville Technical College, the document and binder must be returned to the principal, vocational center director, or department head so the instruction guide may be used by replacement personnel.

Corrections, modifications, and notes may be made on the pages of the documents for the purpose of modifying the field trial edition or to improve the instructional value of the document. Please, share any corrections or modifications to the document or share your recommendations with the Occupational Education Articulation Program.

Illegible or blank document page replacements may be requested at no cost through the Occupational Education Articulation Program. For replacement pages, please indicate:

Document Title
Module Number
Task Number or Page Number

Replacement costs for this document and binder are:

1" Binder - $2.80
2" Binder - $5.00
Document - .03¢ per page (1982)

Who to contact:

Occupational Education Articulation Program
The School District of Greenville County
c/o Donaldson Vocational Center
Donaldson Center
Greenville, SC 29605
(or)
Consultant, Vocational Education
The School District of Greenville County
(or)
Associate Vice President for Education
Greenville Technical College

BINDER DESIGN

(Occupational Education Articulation Program)

The binder design is simple and straightforward.

Two triangular figures, in balance, represent the two institutions participating in articulation.

Two levels of training are represented by the placement of the triangular figures and the identification of the two institutions.

Horizontal and vertical lines represent lateral and vertical articulation.

The diagonal across the design represents the progressive movement in career development for successful job performance.

The two figures are not closed when they face, but allow for interaction and are linked by the document title: Articulated, Performance-based Instruction Guide.

The binder design was developed by Ed Henderson Jr., Coordinator, Occupational Education Articulation Program.